Sci 2/30

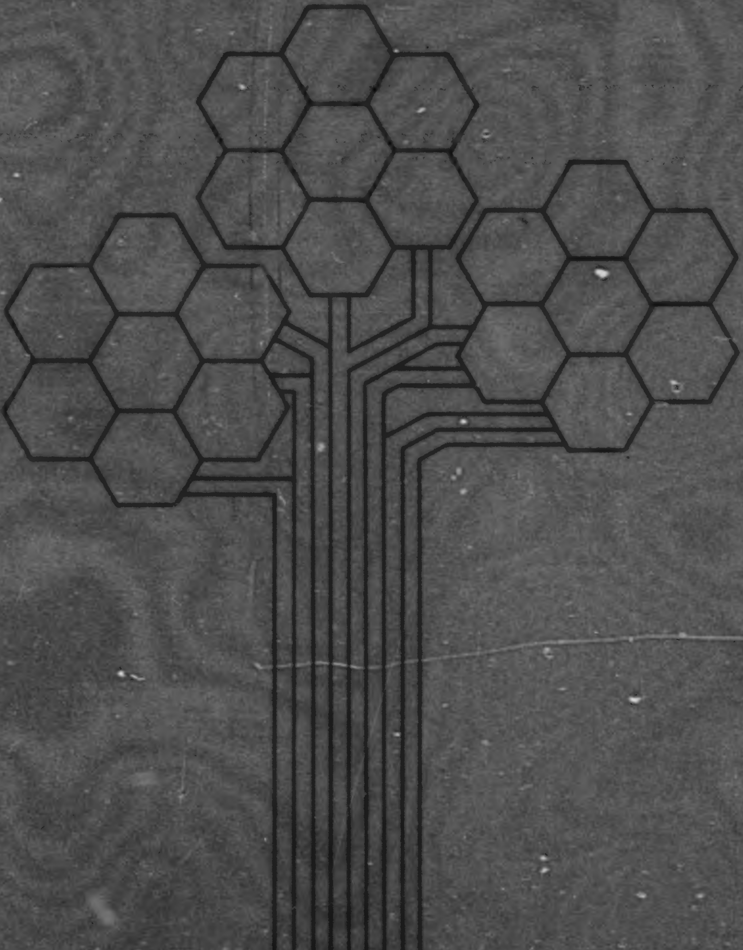
What are the Needs in Precollege Science, Mathematics, and Social Science Education? Views from the Field.

National Science Foundation
Office of Program Integration
Directorate for Science Education
SE 80-9

NEWARK PUBLIC LIBRARY

SEP 30 1980

U. S. GOVT. PUBS.
DEPOSITORY 376



NEWARK PUBL'C LIBRARY

SEP 30 1980

U. S. GOVT. PUBS.
DEPOSITORY 376

NS1.2:

The material in this book is based upon work supported by the National Science Foundation, under the contracts listed below. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

American Association for the Advancement of Science,
Contract No. SED 78-20367

American Association of School Administrators,
Contract No. SED 78-20660

Association for Supervision and Curriculum Development,
P.O. 78-SP-1131

National Academy of Sciences, National Research Council,
NSF C310, T.O. 397

National Congress of Parents and Teachers,
Contract No. SED 78-20656

National Council for the Social Studies,
P.O. 78-SP-1132

National Council of Teachers of Mathematics,
P.O. 78-SP-1130

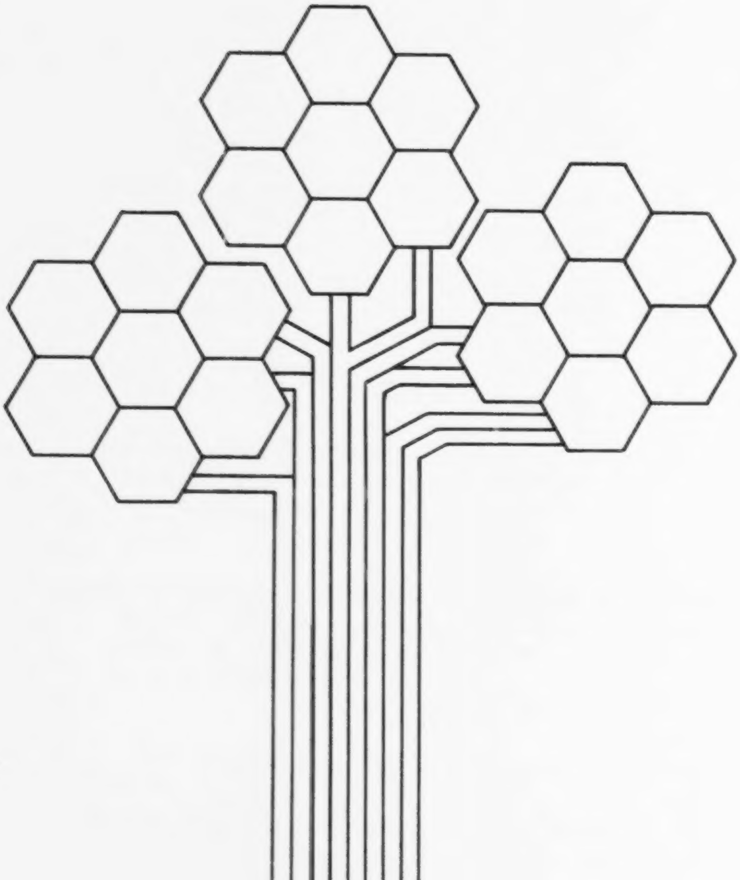
National School Boards Association,
P.O. 79-SP-0658

National Science Teachers Association,
P.O. 78-SP-1133

Reproduction of all or portions of this book is allowed.

What are the Needs in Precollege Science, Mathematics, and Social Science Education? Views from the Field.

National Science Foundation
Office of Program Integration
Directorate for Science Education
SE 80-9



blank page

CONTENTS

Preface
F. James Rutherford v

Introduction
Linda J. Ingison xi

Chapter 1. Teacher Organizations

National Council for the Social Studies
An Interpretive Report on the Status of Precollege Social Studies Education Based on Three NSF-Funded Studies 3

National Council of Teachers of Mathematics
Mathematics Teaching Today: Perspectives from Three National Surveys 19
Mathematics Teaching Today: Perspectives from Three National Surveys for the Elementary Grades 33

National Science Teachers Association
The Teacher is the Key: A Report on Three NSF Studies 43

Chapter 2. Science Organizations

American Association for the Advancement of Science
A Report on the Implications for the Science Community of Three NSF-Supported Studies of the State of Precollege Science Education 55

National Academy of Sciences, National Research Council
The State of School Science. A Review of the Teaching of Mathematics, Science, and Social Studies in American Schools, and Recommendations for Improvements 79

Chapter 3. Administration and Support Organizations

American Association of School Administrators
Summary of the Findings of Three NSF-Sponsored Studies on the Status of Precollege Science Education 123

Association for Supervision and Curriculum Development
Summary and Implications of the National Science Foundation Reports on the Status of Science, Social Studies and Mathematics Education 159

National Congress of Parents and Teachers, National PTA
Report of the Curriculum Review Committee 180

National School Boards Association
Math, Science and Social Studies Curriculum:
Retrospect and Prospects 197

PREFACE

Alarmed and embarrassed by events of the 1950s, the nation seemed to be of a single mind: do something, Washington, to see to it that the United States once again and without a doubt becomes the leading scientific and technological nation in the world—and gets to the moon first!

So be it. Programs were invented, dollars appropriated, people employed, and grants given. Progress was fever charted. For most citizens the measures were successful rocket lift-offs, manned orbits completed, diseases conquered, and Nobel Prizes won. For their part, the scientific cognoscenti marked progress by comparing the U.S. to other countries in terms of prizes won, Ph.D.'s trained, papers published in significant journals, citations accumulated, and science budgets relative to gross national product. And sure enough, by the end of the 1960s, the charts all agreed: we were there! Perhaps we had been there all along, as most of the world seemed to believe, but no matter, Americans had finally come to believe in America's scientific preeminence once again.

In all of this the National Science Foundation, along with the National Aeronautics and Space Administration, occupied stage center. Conceived in the 1940s and born in 1950, the National Science Foundation was in place and ready to go when the nation became concerned about our scientific capability. It located brilliant investigators and got them to work doing imaginative fundamental research. Furthermore, even as the NSF established itself as the premier supporter of basic research, it made what well might come to be regarded as the most inventive contribution of a federal agency to public education since the establishment of the land-grant universities.

To be sure the Foundation entered educational affairs conservatively enough by providing graduate fellowships to the brightest young science students to attract them into becoming research scientists, but quickly it realized that such efforts were insufficient. If a dramatic growth in the science workforce was to be accomplished without reducing its quality, then the entire talent pool from which scientists are drawn had to be enlarged. Scientists discovered at just about the same time as everyone else that there was trouble in the high schools, big trouble, and it was called science teaching. If the country wanted more and better scientists, then something had to be done about science in the schools. The Foundation did in science education what came naturally to it, namely supporting the efforts of outstanding university scientists to develop new science and mathematics courses—new in content, conception, and design—and to educate teachers. Many such scientists become involved, turning their attention from the lab to the schoolroom, and the curriculum improvement effort was underway.

What followed was what many within the house of science have come to regard as the golden age of science education. Action sprung up at schools and colleges across the land. Hundreds of talented persons—scientists, science teachers, psychologists, film makers, writers, apparatus designers, artists, etc.—formed themselves into groups according to shared notions of what high school science might become. At first this meant high school mathematics and the natural sciences, but then it became extended to high school social sciences, and then to elementary and junior high science. The intent of all of this was to greatly enrich science education[1] options on a national scale but not to develop anything remotely like a "national curriculum."

The byword was innovation. Novel materials and new techniques appeared in profusion. They were described, praised and criticized at local and national meetings of science teachers and in their journals; they were tested in classrooms, revised on the basis of student and teacher response, and then retested. And so it went, a very competitive affair, government funded but not government controlled or operated. It captured the attention of school administrators and school boards, the nation's press, and eventually the publishers, apparatus manufacturers and film distributors. Thousands of teachers attended summer and inservice programs, upgrading their knowledge of science and mathematics, learning about the new materials and approaches, sharing techniques with each other, and informing college scientists of their needs and views.

In the process of setting out to bring into high school science courses 20th Century science, a process was invented, and that process was, as we have seen, soon applied to the entire range of grades and scientific subjects in this country, and then borrowed worldwide. By 1970, after a heady decade and a half, the U.S. had established a preeminence in science education to match its status in basic scientific research.

As the perception grew, however, "that we were there," that the job had been done, the effort slowed down rapidly by the middle of the 1970s. But all along, and increasingly in the last few years, other voices were claiming that only part of the job had been done, and that NSF should get back to work in science education. After all, we may have learned how to find, motivate and train bright young people to become good scientists and engineers—but how many of them were minority persons or women? The record was dismal. And what about all those children who were not heading toward science careers? Had not their science education been neglected during "the golden age" even though we knew full well that good citizenship and a full life in today's world calls for a decent science education? Such questions, aided and abetted by growing concerns about the general quality of public education and by dramatic and puzzling changes in the economics and demographics of our country, strongly suggested that the time had come to find out just what the situation actually was in regard to science education in the United States.

To find out, the Foundation funded a Status Study as three major independent but related studies to be conducted in parallel. The result, eighteen months later, was nearly 2000 pages of materials organized into seven volumes. Published by the National Science Foundation, the collection is entitled *The Status of Pre-College Science, Mathematics, and Social Studies*[2] *Education.*

To help us make use of the Status Study for our own policy-making purposes, and as a way to get help in the communication of the findings of the studies in useful ways to different audiences, we selected nine organizations to analyze the studies independently and write reports. NSF attempted to maximize the scope of these reports by choosing organizations with different responsibilities and perspectives. These were:

TEACHER ORGANIZATIONS

National Council for the Social Studies

National Council of Teachers of Mathematics

National Science Teachers Association

SCIENCE ORGANIZATIONS

American Association for the Advancement of Science

National Academy of Sciences

ADMINISTRATION AND SUPPORT ORGANIZATIONS

American Association of School Administrators

Association for Supervision and Curriculum Development

National Congress of Parents and Teachers

National School Boards Association

Their reports are included in this volume just as they were submitted. We believe that they present an interesting and informative view about the totality of science education in American schools, and much about the school situation in general.

These nine reports are not only descriptive, they are also normative. Each organization was asked to extract from its analysis the major needs in science education from the point of view of its membership. Thus collectively the reports give us an idea of what problems and issues are thought to be most important, what the system's strengths and weaknesses are believed to be, and what the most important strategies for improvement might be. Although the formats for each report differ they all contain, either explicitly or implicitly, a set of recommendations for the improvement of science education.

In this preface I will make no attempt to summarize the almost 200 pages of tightly worded text that it introduces—let each report speak for itself. However, I would like to offer a few statements taken directly from the reports, statements that I personally found to be intriguing or provocative. For convenience, they are grouped into those bearing broadly on all of precollege education and those on science education specifically.

Among the statements commenting on precollege education in general, the following examples are illustrative:

The Back to Basics Movement

Science education is not viewed as 'basic' by the general population or educators. Concern for science education is included in the category of 'fundamental knowledge in other areas,' which is considered the catch-all for all other subjects not deemed to be 'basic.'

American Association of School Administrators

Though emphasis on acquiring basic skills is at the heart of the educational process, there is a distinct possibility of basics becoming the curriculum rather than just part of the curriculum. Another problem, with an overemphasis on basics, is a tendency to teach children only those things for which they will be tested, a tendency that leads to mediocrity.

National Congress of Parents and Teachers

Student Motivation/Discipline Problems

The NSF case studies observers also found much apathy among students. In some schools, a lack of academic motivation was revealed by low attendance rates and the refusal of many students to attend school on a regular basis. Other students displayed their apathy towards school through passive non-involvement in classroom activities.

National Academy of Sciences

Quality of Education

There needs to be a reaffirmation of a concern for quality in education. The egalitarian philosophy reflected in many educational practices has had the unfortunate effect of encouraging regression toward mediocrity in many parts of the school curriculum. Efforts to reverse this regressive trend are starting. They should be encouraged and supported.

American Association for the Advancement of Science

Lack of Support Structure for Teachers

Supervisors at the secondary level revealed a preponderance of administrative and teaching loads over supervisory tasks....On the average supervisors had in excess of 200 teachers with whom they worked. There were very few people available outside the classroom to provide quality control for the curriculum and assist teachers with pedagogical problems.

Association for Supervision and Curriculum Development

Other factors mentioned in the reports include declining enrollments, finance problems, increased emphasis on equal educational opportunity and the multiplicity of tasks that the schools are expected to perform.

Among the statements commenting on science education specifically, the following examples are illustrative:

Curriculum

In summary, some readers will conclude that one of the major inferences that can be drawn from these reports and case studies is that much of the secondary school science curriculum is mismatched to the interests and needs of the majority of students in our schools who will not pursue scientific or technological careers.

National Science Teachers Association

Teachers

...Individual teachers have a great deal of freedom, often more than they recognize or wish to admit, in deciding what social studies will be....When we try to describe what happens to students in social studies classes, then, the ever-present reality is the teacher, interacting with students and deciding, day-by-day and moment-by-moment, what will happen in class.

National Council for the Social Studies

Instruction

Mathematics teachers have been urged to implement discovery learning, mathematics laboratory activities with 'hands on' learning, individualized instruction, multimedia instruction, and many other promising pedagogical strategies. However, as is the case with attempted changes in the content of school mathematics, the NSF studies provide reason to question the extent to which any of the proposals for innovative pedagogy have influenced predominant instructional patterns.

National Council of Teachers of Mathematics

Finances

> *...The researchers conducting the science study for NSF conclude, based on past patterns of state and federal funding, it is not likely that many states will give science a high priority since federal legislation does not.... The percentage of state support for science education has remained virtually unchanged since 1955.*
>
> National School Boards Association

Other issues mentioned in the reports include: adequacy of facilities and materials, preservice and inservice teacher training, and elitism vs. populism in the science curriculum.

I believe that these reports can play a role in helping us understand the shape of American science education as we enter the 1980s. They contain information about both where we have been and where we should be headed. It is a pleasure to share them with you.

F. James Rutherford
Assistant Director for Science Education
National Science Foundation
December 1979

---

[1] Unless otherwise specified subsequent references to "science education" include natural science, mathematics, and social science education.

[2] The Foundation's interest is in social **science**. Because this is embedded in social **studies** in precollege education, the Status Study contains some information in the broader area.

blank page

INTRODUCTION

What Are the Needs in Science Education? Interpretations from the Field

Linda J. Ingison
National Science Foundation

This report is the eighth and final volume in a series based on the National Science Foundation's Status Study of Precollege Science, Mathematics, and Social Studies[1] Educational Practices in U.S. Schools. The study was sponsored by the Science Education Directorate. Included in this volume are commissioned reports prepared under the auspices of nine organizations having a major interest in the conduct and quality of precollege science education.[2] Reports are included from the National Council for the Social Studies, the National Council of Teachers of Mathematics, the National Science Teachers Association, the National Congress of Parents and Teachers, the National School Boards Association, the Association for Supervision and Curriculum Development, the American Association of School Administrators, the National Academy of Sciences and the American Association for the Advancement of Science.

Phase I—The Status Study

The study that led to the present compendium of reports was initiated in 1975. That year, in response to program planning needs within the Science Education Directorate, the decision was made to take a retrospective look at the state of precollege science education in U.S. schools, as well as at the changes that had taken place over approximately twenty years of vigorous reform efforts. The final outcome was the NSF Status Study of Precollege Science Education.

Planning for the Status Study was accomplished with the assistance of members of the scientific and educational community as well as NSF staff. A planning meeting was held in Washington, D.C. in 1976 to outline the goals of the study. The general purpose of the planned study was to determine what really happens in schools in science education. In addition, the effects of reform and change efforts instituted by numerous groups at all levels in the educational establishment in the late 1950s and the 1960s were to be assessed. Within these broad goals, several more specific questions were considered of importance. These questions centered around the usage of curriculum materials; the training, inservice, and preservice support available to school personnel; the position of science with respect to other disciplines in school, district, and state priorities; and the amount and quality of support of all kinds for science education. In short, the Status Study was planned to provide a general but comprehensive picture of science education today and over the past two decades.

The Status Study was conceived as three independent but related studies utilizing differing methodological approaches and drawing on different data bases. Requests for proposals were prepared for case studies of science education practices, a survey of educational practitioners, and a literature review focusing on published and unpublished documents pertaining to science education issues and needs. Awards for the conduct of the three studies were made to Drs. Robert Stake and Jack Easley at the University of Illinois, Dr. Iris Weiss of Research Triangle Institute, and Dr. Stanley Helgeson of the Ohio State University for the case studies, survey, and literature review, respectively. Final reports of these studies are available (see reference list) and constitute the first seven volumes referred to above.

Phase II—The Commissioned Reports

While conceived of as a planning study for the Foundation, the detail and richness of the data contained in the Status Study represent a unique resource to the field as well. First, the Status Study reports provide a comprehensive and detailed picture of science education as practiced today with indications of the forces impinging on the system. Second, much of the data provided in the reports is perishable in a real way, as schools and schooling are continually changing. Finally, much of the data collected is unavailable from other published services.

However, the final reports themselves were felt to be prohibitively large and expensive to receive extensive use by all those interested in precollege science education. In addition, the Status Study reports were designed to provide discussions of current status rather than future needs in science education. For the latter, interpretations in light of possible futures would need to be done by knowledgeable individuals and groups. The reports in this volume represent a first attempt to provide such interpretations.

Phase II had two broad purposes. The first goal was to disseminate information about the existence and availability of the Status Study volumes themselves. More than a simple dissemination effort was intended, however. Another primary goal of Phase II was to enlist the chosen organizations in not only summarizing the major findings of the Status Study, but also in extrapolating from these results the major **needs** in science education **from the point of view of each organization's membership**. This goal gave the Phase II effort its uniqueness. The reports were not commissioned for the use of the Foundation, but rather to stimulate awareness and use of the data by those in the field involved with science education.

Planning for the Phase II effort began with identification of the various groups that traditionally are interested or active in science education. The major target groups included students, parents, teachers, administrators, supervisors, curriculum developers, school boards, and scientists. While there are numerous organizations and associations representing one or more of these (or other) groups, finite resources forced us to limit selection In general, we attempted to involve a wide variety of points of view, and to maximize dissemination to the largest number of potentially interested individuals.

Each organization was asked to prepare a plan for the development of an interpretive report based on the Status Study. The proposal was to specify the involvement of several well-known and well-respected organization members in actually preparing the report, as well as to include plans for publishing the resulting report in one or more of the organization's own publications. Therefore, while the basic process of preparing the nine reports that follow was similar, the reports themselves vary in both style and content. Stylistic variation resulted from the editorial demands of the particular publication chosen by each organization. The content of each report also varies, due in part to the specific manner in which each committee approached the task. Some organizations consciously chose committee members with expertise in each of the three subject areas (i.e., science, mathematics, and social science) covered in the Status Study, and charged each contingent of experts with developing subject-specific summaries and needs statements. Others approached the task by assigning particular committee members responsibility for one of the three substudies of the status report (i.e., case study, survey, or literature review). Still others involved the full committee in working on all three reports simultaneously. Further variation among the reports can be attributed to differences in the degree to which the committees ultimately viewed the task as one of summarization of the major findings or as one of developing needs statements based on such findings. The reports differ in the degree to which each committee was able to develop recommendations that are relevant to the sponsoring organization's membership, and the degree to which such recommendations are action-oriented and specific. All but one of these reports have been previously published, in some cases as an article or series in the organizations' journals, in others as a separate report. These published reports typically went through organizational review as part of the process of becoming official reports.

Our expectation was that each organization would see the data from a somewhat different perspective, and therefore define differing science education needs and recommendations. The texture and variety of the reports to follow attest to the accuracy of this expectation. Our hope was to not only make the educational and scientific community aware of the reports but also to stimulate research, professional activity, and greater involvement in science education. From our perspective, early signs indicate that our efforts to interest and involve the educational community have been a success.

The reports to follow are presented in this volume as they appeared in their original publications. We have made no attempt to edit or to summarize the statements made by the nine chosen groups. Instead, our purpose in compending this volume is to facilitate access to all nine summaries and interpretations. Any opinions, findings, conclusions or recommendations expressed in the nine reports are those of the authors and do not necessarily reflect the views of NSF.

---

[1] The Foundation's interest is in social science. Because this is embedded in social studies in precollege education, the Status Study contains some information in the broader area.

[2] Unless otherwise specified, references to "science education" include natural science, mathematics, and social science education.

References

It is suggested that the Government Printing Office is the best source for printed copies. These can be ordered by title only, but inclusion of stock number and price (when available) is helpful.

The address is:

U.S. Government Printing Office
Washington, D.C. 20402

These documents are also available in printed or microfiche form from:

ERIC Document Reproduction Service
P.O. Box 190
Arlington, VA 22210

National Technical Information Service
(NTIS)
U.S. Department of Commerce
Springfield, VA 22151

- The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies.

  GPO Stock Number 038-000-00383-6, $3.50

- Case Studies in Science Education. The Case Reports.

  GPO Stock Number 038-000-00377-1, $7.25

- Case Studies in Science Education. Design, Overview and General Findings.

  GPO Stock Number 038-000-003763, $6.50

- Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education.

  GPO Stock Number 038-000-00364-0, $6.50

- The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Science Education.

  GPO Stock Number 038-000-00362-3, $4.25

- The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Mathematics Education.

  GPO Stock Number 038-000-00371-2, $4.50.

- The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Social Science Education.

  GPO Stock Number 038-000-00363-1, $6.25

Chapter One
Teacher Organizations

National Council for the Social Studies

Introduction 3
I. Curriculum and Classroom Practice 5
II. Teachers' Views of Social Studies and Schooling 8
III. Divergent Views of Academicians, Curriculum Developers, and Teachers 10
IV. Research 13
V. Conclusions 15

National Council of Teachers of Mathematics

Mathematics Teaching Today: Perspectives from Three National Surveys

Introduction 19
Course Content and Enrollments 20
Patterns of Instructional Style 22
Teacher Abilities, Attitudes, and Beliefs 24
Changing School Mathematics 28
The Task Ahead 30

Mathematics Teaching Today: Perspectives from Three National Surveys for the Elementary Grades

Introduction 33
Content Emphasis in Elementary Mathematics Programs 34
Patterns of Instructional Organization and Style 35
Perceptions of the Abilities, Problems, and Beliefs of Teachers 39
The Task Ahead 41

National Science Teachers Association

Introduction 43
How Do Teachers Teach? 43
What Do Teachers Teach? 44
How Are Teachers Educated? 46
Who Helps the Teacher? 47
With What Do Teachers Teach? 48
Whom Do Teachers Teach? 49
Do Teachers Count? 49
What Can Be Done? 50

An Interpretive Report on the Status of Precollege Social Studies Education Based on Three NSF-Funded Studies

James P. Shaver, O.L. Davis, and
Suzanne M. Helburn

Introduction

The central interest of the National Council for the Social Studies is the education of children and youth—what happens to students as a result of their school-related experiences, especially in social studies programs. Questions—both quantitative and qualitative—about the nature of those experiences across the nation are frequently asked by and of National Council for the Social Studies (NCSS) members. The answers must often be either a pointed, "I don't know," or conjectures based on limited personal experience. All too rarely are data available that permit well-substantiated statements. In 1976, the National Science Foundation (NSF) funded three projects, each based on different methodological approaches, to investigate status in science, mathematics, and social science/social studies education. Taken together, the reports from the studies provide a substantial remedy for the lack of information about social studies.

Although most educators probably date National Science Foundation involvement in education from the efforts following the launching of Sputnik I in 1957, NSF has been concerned with precollege science education from its inception in 1950. Much of the NSF-funded curriculum development work and many of the teacher institutes have been in chemistry, biology, physics, and mathematics; however, the social sciences have also been given attention. And, at the elementary and secondary level, NSF has tended to define social science education as the K-12 social studies curriculum.[1]

NSF involvement in curriculum development has not been without controversy, especially in the last few years. Some critics have raised questions about the impact on elementary and secondary education relative to the amounts of money spent. Some have worried about the potential of a nationally imposed curriculum. Others have questioned the appropriateness of the content of the NSF curricula, based as it has been on the academicians' views of their disciplines. And some have argued that NSF materials, such as those developed by the Man—A Course of Study (MACOS) Project, were out of step with and subversive to the legitimate values of many families. These disputes over NSF curricular efforts have created considerable political, especially Congressional, pressure on the Foundation to redirect or restrict its curriculum development and teacher education efforts. In light of the various conflicts and pressures, the NSF Education Directorate decided, in 1976, to take soundings on the status of science education to provide a more substantial factual basis for charting its future directions.

As had been the case in prior NSF curriculum development and teacher education efforts, the studies of the status of science education initiated by NSF in 1976 included social studies education. NSF varied the orientation and methodology of the studies intentionally to provide differing perspectives on the nature and needs of science, mathematics, and social studies education.

One of the funded studies was a national survey of administrators and teachers (referred to henceforth as the National Survey)[2] to obtain responses to questions about such matters as the courses offered, the textbooks and materials used, the time spent in teaching different subjects, and the impact of federally supported inservice education on science, mathematics and social studies education. The study used sophisticated survey instrument development and probability sampling techniques, and produced an abundance of data that present a quantitative perspective based on self-reports of what is happening in social studies.

This report originally appeared in *Social Education*, Volume 43, Number 2, February 1979.

The second set of studies reviewed the research literature produced from 1955 to 1975 for its information. Three separate reviews of the research literature were conducted—in science, mathematics, and social science/social studies education.[3] (The social studies research review is henceforth referred to as the Review.) Each review was to summarize what the literature had to say about such matters as status and trends in instruction, the effectiveness of instructional practices, the perceptions of needs in the curricular area, and teacher credentialling and training. Limits on time and personnel precluded reviewing all of the relevant original research reports, so considerable reliance was placed on previously reported reviews of research.

The National Survey and the reviews of research fit rather traditional modes of educational inquiry. The third study did not, although its methodology has been receiving increased attention among educational researchers in recent years. The study[4] (referred to henceforth as CSSE) involved field observations at eleven sites—each including a high school and its feeder schools—in order to portray teaching and learning conditions in science education through the ethnographic, anthropological style of participant observation. The sites were selected to provide a diverse but balanced (rural/urban, geographic, ethnic, socioeconomic) representation of American schools, and to ensure that an experienced field researcher was available to be onsite for a substantial period of time. In addition, a national survey, with questions based on the field observations, was conducted to confirm the ethnographic case findings.

Although the NSF Education Directorate's primary goal in sponsoring these three studies with their diverse methodologies was to obtain status data that would be helpful in developing its own policy and program decisions, it was clear that the reports contained substantive findings and much about methodology of potential interest to educators. The three status studies under review undoubtedly constitute the most ambitious and extensive studies ever conducted on the status of science, mathematics, and social studies in American schools. For that reason alone they are notable. Because of the different methodologies each employed, they raise different questions and cast different light on a number of conclusions of potential interest to readers. Moreover, CSSE represents the first major, large scale application of ethnographic procedures in educational research in this country. Some of the eleven case studies are better done than others; yet each is interesting and revealing taken alone. And the synthesis chapters in the report are exciting reading as they build meaning by drawing from and interweaving the individual case studies. To alert the education community to the existence of the studies and their possibilities for comprehending schooling in this country, NSF invited the National Council for the Social Studies and eight other professional educational organizations to prepare brief interpretive papers. Each paper was to be targeted at the organization's members and other educators with related interests.

Our intents in preparing this paper were: (a) to convey as reliably and accurately as possible a picture of status and needs in social studies education as revealed by the three studies; and (b) to encourage other social studies educators to go to the reports to study for themselves the rich data base and to ponder over the implications for educational practice and research.

In preparing such an interpretive paper, and with a mandate to be brief, it did not seem feasible or appropriate to summarize in detail and footnote the many findings cited in the over 2,000 pages of the reports from the three studies. On occasion, we have provided general references to guide readers to passages which stimulated our impressions.

This paper is not intended as a critique of the studies. Our purpose was to interpret, not to criticize. We did have some hesitancy about relying too heavily on the self-reports obtained in the National Survey as indications of what **is** happening rather than what people would like to think or have others think is going on. We wondered about the biases that may have been injected into the review of research in social studies education by the reliance on prior reviews of research, rather than on original reports. And the case studies involved personal, experiential data-gathering techniques whose validity for producing replicable and generalizable views of educational practice is not yet clearly established. Despite these reservations, we found that generally the three reports confirmed one another. Interestingly, in our discussions of the major ideas to be presented in this paper, we found ourselves relying heavily on the case studies material for our first line of impressions—suggesting the richness we found in ethnographic-type findings. But the sources of the impressions about the status of social studies which we elaborate on the following pages can be found in all three reports.

An important reservation about this paper must be stated openly and clearly. Any attempt to sketch a general description of social studies education from three comprehensive project reports, such as we reviewed, must be viewed with caution. We were continually impressed with the enormity of the task and with the great difficulty of doing justice to the immense amount of data and to the complex variety of teachers, students, and classroom circumstances they represent. In an introductory paragraph to the CSSE Executive Summary (Ch. 19), the authors lament the need to prepare that condensation:

> *Having already partially mutilated the delicate and complicated portrayals of happenings and feelings as drawn together by our field observers by attempting to sort and aggregate them in our findings chapters, we now further oversimplify by presenting them in grand summary. We urge the reader who is appreciative of the problems and efforts of precollege education to read the complete case studies.*

We were similarly concerned in producing this further rendering of all three studies.

It has been difficult to do justice to the magnitude and richness of the data. Exceptions to our general statements will not be hard to find in specific schools. And other persons, analyzing the reports from different perspectives, will come up with different emphases and—not frequently, we trust—divergent, even conflicting, interpretations. To acknowledge the constraints on our review and interpretations of the studies, we have consciously chosen to write this paper in the first person, rather than using the more detached third-person pronouns common in such documents. We urge readers to turn to the reports themselves to confirm, disconfirm, and/or add dimension to the impressions given on the following pages, and to use the wealth of meaning there to build their own understandings of social studies education.

We have divided the paper into five sections. The first three sections are primarily discussions of status, although needs are implied. (The nature of those needs will often depend, of course, on the frame of reference of the reader.) Section I gives our impressions of the social studies curriculum and classroom practices in our nation. Section II discusses teachers' views of the school and of social studies. Section III contrasts teachers' views and concerns with those of academicians, curriculum developers, and district supervisors. These divisions were made for the purpose of organizing our comments, and the sections are highly interrelated. Section IV discusses the state of research in social studies education. And in Section V, Conclusions, we comment on our overall portrayal of social studies education.

I. Curriculum and Classroom Practice

Obviously, the focus of schooling is students; its intent is to influence their learning. An inquiry into the status of social studies education, it seemed to us, must center on the primary question, What is happening to the students? Other questions are peripheral and gain interest only as they relate to that central question. The three NSF-funded studies reveal a great deal about the types of experiences youngsters are likely to be having in social studies classes.[3] The impressions that follow were sometimes confirmations of our prior understandings of social studies. Often, however, they were contradictions or new insights.

The Central Role of Teachers. The reports remind us that "The teacher is the key to what social studies will be for any student" (CSSE, Ch. 19). The teacher's beliefs about schooling, his or her knowledge of the subject area and of available materials and techniques, how he or she decides to put these together for the classroom—out of that process of reflection and personal inclination comes the day by day classroom experiences of students. This is not to say that social studies classes are not affected by factors such as the characteristics of the students enrolled, but only to emphasize that the teacher plays the primary structuring role.

The three NSF-funded studies confirmed the view that individual teachers have a great deal of freedom, often more than they recognize or wish to admit, in deciding what social studies will be. Teachers do lack control of the budget and so are restricted in introducing new programs (the CSSE and National Survey studies both found that teachers felt their choices of materials were seriously restricted by the budget). Nevertheless, their part in the textbook adoption process and their position as the arbiters of what goes on in their classrooms allow teachers to effectively veto curricular changes of which they do not approve. When we try to describe what happens to students in social studies classes, then, the ever-present reality is the teachers, interacting with students and deciding, day by day and moment by moment, what will happen in class.

Federally-funded Projects. Despite the fair amount of federal funding for curriculum development since the late 1950s, one experience that the social studies student is not likely to have is interaction with curriculum materials produced by federally funded projects, especially those funded by NSF.[6] Only a small portion of social studies teachers seem to be aware of what has been termed the New Social Studies, and the proportion of users is, as one might expect, even smaller. The self-reports of the National Survey (Ch. 4) and the results of the Review (Sec. 4.0) indicate that from ten to twenty-five percent of teachers were using at least one of the federally funded New Social Studies materials.[7] The percentages are less for NSF-funded materials. None of the eleven CSSE school districts were using HSGP, SRSS, or the NSF-funded anthropology materials. However, the National Survey and CSSE provide no information about the influence of New Social Studies ideas on conventionally produced textbooks, or on teacher training. The Review notes a lack of systematic research on these possible indirect influences of the New Social Studies movement.

The Textbook as Central. Concern with the content and orientations of textbooks is not trivial, for the textbook is the dominant tool of instruction—the basis for recitation, discussions, and for student testing. Although the Review indicated that there may have been more variety in teaching methods during recent years than many thought, the CSSE field observers found little to verify that claim. Furthermore, the National Survey (Ch. 5) found that the most commonly used texts are the "traditional" ones and that around fifty percent of the teachers reported using a single textbook. Slightly over fifty percent (sixty percent in grades ten through twelve) of the teachers reported that they would continue using the same textbook or program if given free choice. Also, roughly twenty to thirty-five percent of the teachers reported using texts which were over five years old. But they also did report (Ch. 7) that out-of-date teaching materials were a major problem.

Subject Matter Focus. The social studies curriculum still seems to be mostly about history, government, and, particularly at the elementary level, geography, with slight attention to current social problems. Students tend not to encounter interdisciplinary teaching; teachers do not typically draw material from the various social sciences, much less from the natural sciences. And, current, controversial issues—particularly those viewed as off limits by the local community, but national ones as well—are rarely dealt with. As noted above, the emphasis tends to be on topics presented in the textbook. Finally, there is little evidence of "fragmentation"—if that term is used to refer to the proliferation of new courses and topics to study, the use of mini-courses, and multiple readings from paperbacks—at the expense of traditional coverage. At the twelfth grade level, the American problems course has frequently been replaced with "social science" offerings, such as psychology, sociology, and economics.

Objectives and Teaching Strategies. Knowing for the student is largely a matter of having information; and the demonstration of the knowledge frequently involves being able to reproduce the language of the text in class discussions or on tests. Experience-based curricula, despite recent professional writing about learning through participation, appear to be rare. Lecture and discussion are the most frequently reported teaching techniques (National Survey, Ch. 6; also see the Review, Sec. 1.3), with activities such as field trips and simulations used much less often. "Inquiry teaching"—with its variety of meanings—was also not commonly seen by CSSE observers nor reported by National Survey respondents. Large group, teacher-controlled question/answer recitations are customary. (From fifty to sixty percent of the respondents indicated they needed help if they were to implement inquiry teaching, and only ten percent of the total indicated that adequate help was available.)

The textbooks that students read and the recitation that follows in most social studies classes still are content, i.e., information, oriented. There is little attention to the development of systematic modes of inquiry and reasoning, including valuing. CSSE observers saw some efforts to get students to think for themselves and develop their own reasoning powers; but more often students were asked to respect understanding that came from others, supposedly validated, but by processes that were not explicated, much less brought into the classroom discourse to be applied by students.

Affective learning objectives were rarely an explicit part of the curriculum in the CSSE schools. Implicitly, the thrust of textook use and teacher-initiated interactions was to teach students to accept authority and learn the "basic" facts and conclusions about our history and government. The CSSE authors concluded (Ch. 15) that "book learning" is the objective—children and youth are to be disciplined to learn expeditiously from printed materials.

Motivation and Student Interest. As a corollary to the mode of teaching discussed above, motivation is largely external. One learns for grades, for approval, because it is the thing one does at school, or to get into college. That students will learn through intrinsic motivation—because information or skills are useful for coping with problems of personal importance, or to satisfy curiosity—is not a common assumption among teachers. This is particularly noteworthy since the Review and CSSE both disclose that students still report social studies to be uninteresting.

Despite being treated as nonself-starting learners, students are likely to find one common denominator among their social studies teachers, as with mathematics and science teachers: that is a concern for young people. Teachers like their students, and are interested in their well-being, personally and academically. However, secondary school teachers are more likely than elementary ones to be concerned with covering subject matter rather than helping each student do his or her best. Still, they tend to create a comfortable environment for their students, and students often like their teachers, even while lacking interest in the subject matter.

Status of Social Studies and Science. It seems clear that, particularly in the primary grades, both social studies and science are losing instructional time in elementary schools because of the increasing emphasis on the "basics," defined as reading and arithmetic. Social studies fare somewhat better than science because language arts and reading material often incorporate social studies topics. Furthermore, elementary teachers, who typically include the inculcation of social skills and attitudes as part of social studies, do involve students in experiences relevant to that goal. Surprisingly to us, the CSSE teachers agreed with the back-to-basics movement. Even in the high schools, where subject matter specialization is important to teachers, reading is seen as a prerequisite to the adequate learning of content, and so deserving of greater attention as a "basic."

An interesting contrast between social studies and science is prevalent at the secondary school level. Social studies courses are regularly required each year as part of general education, but only general biology (in the tenth grade) seems to get this treatment in science. Chemistry, physics, and advanced biology courses are electives, and clearly part of career training—preparation for college or for science-related careers. On the whole, social studies courses are not organized sequentially to train students in social science or for social science-related careers. Consequently, while science courses emphasize laboratory methods—although often of the follow-the-cook-book variety—there is little attention in social studies to social science research methodologies. And, one social studies course is rarely "more advanced" than another; most tend to be geared to a level at which nonacademically inclined students can obtain a passing grade and fulfill graduation requirements. This, too, may have implications for the lack of student interest.

Females and Minorities. Those wondering what is happening to ethnic minority students and females in social studies, science, or mathematics classes will not find much information in any of the three NSF-funded reports we reviewed. The usual sex differences in achievement scores and enrollment in science and mathematics classes are mentioned. CSSE does report some indications of increased enrollment by females in science classes in the case study schools, but not that girls like those subjects any better. There are expressions of concern about motivation among lower socioeconomic and non-English-speaking minorities. But little is revealed about how these students fare in classrooms. In fact, in reading the CSSE report, we often sensed a tendency to avoid mention of the ethnic identity of students. The National Survey and the Review say even less about the classroom experiences of ethnic minority students and females.

Recapitulation. Some students may be experiencing social studies classes in which they use products from the various New Social Studies projects, actively participate in teacher-guided in-class and out-of-class learning experiences as a basis for formulating and learning knowledge, and take part in "inquiry" discussions and exercises where they learn standards and means for validating knowledge. More likely, however, the students' social studies classes will be strikingly similar to those that many of us experience as youngsters: textbook assignments followed by recitation led by a teacher who, in his or her own way, likes students and tries to show concern for them—and voids controversial issues, but tries to pitch the class at the students' level.

A sense of stability emerges from the three status studies—a lack of change in social studies instruction over the years that was unexpected by us. This stability may be interpreted by many social studies educators as an overwhelming defeat for the reform efforts of the 1960s and early 1970s and the irrational persistence of outmoded, dysfunctional patterns of materials and teaching. Such a conclusion probably does not take adequate account of the complex realities of social studies in the schools. There have been dramatic changes in some school programs, and exciting teaching is going on in many places. But fundamental, far-reaching changes do not occur easily in as vast and governmentally decentralized an enterprise as American public education. Also, our perspectives may be too limited at this point in time to judge the long-run impact of that reform movement. Moreover, some of the stability in the social studies curriculum may reflect desirable responses to legitimate societal needs for the socialization of the young. Certainly, such considerations make it clear that teachers' views of school and social studies are critical to an appraisal of the status and needs of social studies education.

II. Teachers' Views of Social Studies and Schooling

Our impressions of teachers' views of social studies and of schooling have been touched on in our discussion of curriculum and classroom practice. For example, it should come as no surprise at this point that the CSSE field observers (e.g., Ch. 12) found teachers to be primarily concerned that their students learn the content, the subject matter of the field being studied. In essence, although general statements of educational goals include items such as the development of inquiry skills, the teachers' major concern is with the students' learning of an accepted body of knowledge. For that purpose, teachers tend to rely on, and believe in, the textbook as the source of knowledge. Textbooks are not seen as support materials, but as **the** instrument of instruction by most social studies teachers.

Texbooks and Inquiry. The teachers' view of the textbook as authoritative undoubtedly stands in the way of their involving students in inquiry. But that is not the only factor. The hands-on, experience-centered learning of many inquiry-oriented curricula is seen as too demanding of students; too much is often expected of students at their level of intellectual development and, probably even more important, self-discipline. From such a stance, inquiry teaching is nonproductive. Time is wasted when students are allowed to formulate problems and pursue their own answers; and the few hours for instruction are too precious to be squandered in that way. There is so much content to be learned.

Another factor in social studies teachers'views of the importance of transmitting knowledge as contrasted with teaching students to inquire and reason, is that they are not likely to be model inquirers themselves. (Remember that a large proportion of the teachers in the National Survey reported assistance with inquiry teaching as a need.) This should be no surprise, given the teachers' own schooling. Undergraduate history and social science college courses, as well as precollege courses, rarely involve students in active consideration of penetrating questions about the validity of knowledge. Nor is laboratory or field research commonly a part of such courses. As elementary, secondard, or college students, prospective teachers do not experience systematic scientific or other—e.g., ethical—inquiry, nor teachers who model the encouragement of such questions from students. The teachers' own education conditions them to perceive the appropriate role of the student as productive—i.e., doing assignments and learning content—subordinate, rather than independent speculative thinker and investigator. This view of social science and history academic role models as a conservative force working in opposition to the social studies reform movement of the 1960s is in contrast with a tendency in the social studies literature to characterize social scientists as promoting the use of historical/scientific inquiry methods by students. This dominant influence on teachers' perspectives must be considered by those interested in changing the current mode of social studies instructions.

Controversial Issues. It would be a mistake to think that parents are upset by social studies teachers' transmission-of-knowledge view of education. For the most part, parents are comfortable with teaching aimed at passing on knowledge accumulated by others, rather than at encouraging students to raise creative challenges or think critically. In fact, despite the long history of concern by the National Council for the Social Studies for academic freedom and the teaching of controversial issues, and the conclusion in the Review (Intro., Sec. 1.2) that "social studies educators" agree that dealing with controversial issues in the classroom is a particularly significant problem for social studies teachers, few of the CSSE teachers reported problems in that area. Generally, they were quite sensitive to the values of the community in which they taught (it appeared that, in fact, such sensitivity was a common criterion, explicit or not, in the hiring of teachers), and had little trouble presenting their subject matter without affronting local feelings. Communities expected that teachers would venture some distance into uncomfortable topics; but the "tactfulness" on the part of most teachers in handling some issues and avoiding others precluded confrontation, making even the occasionally "radical" teacher tolerable.

This avoidance or diplomatic handling of controversial issues by social studies teachers should not be viewed as cowardice or moral irresponsibility on their part. In fact, it fits with the view that the subject matter of the textbook is the regular business of the classroom, from which one should not be distracted.

Another possible explanation for the tendency to avoid controversial issues, it occurred to us, is the influence of a continuing emphasis in social studies on history, government, and geography. Economics and sociology tend to be more policy/issue oriented disciplines; anthropology often strikes directly at ethnocentrism. Or, it could be that the failure of these social sciences to impact the curriculum is due to the same view that leads teachers to avoid controversial issues *per se*.

Perhaps most important of all, the lack of concern with controversial issues squared with another central element in the teachers' views of their role. One of the most consistent CSSE findings was the concern on the part of teachers with what was termed the "socialization" of their students.

Socialization. Efforts at socialization have two different but related aspects. One is primarily school-oriented; the other is citizenship-oriented. The first has largely to do with the preparation of students for "something to come." For example, seventh graders have to be prepared for the eighth grade, especially for the eighth grade teachers' expectations. (Failure to do so reflects on both students and teachers.) Students also have to be ready for the skill and content demands of future courses. One reason for the central place of instructional materials, especially the textbook, is the belief that preparing students for later success requires teaching them to learn from such material. Generally, the concern is with helping students learn to adapt to the schooling system, which it is assumed demands order and discipline for effective learning.

Accompanying beliefs are that extrinsic motivation is essential if students are to pay attention to their school work. Teachers believe that the personal make-up of students and the home situations from which they come militate against a more idealistic reliance on intrinsic motivation. Students must learn to pay attention to directions, to questions, to classroom presentations as a basis for future learning; learning to carry out assignments is crucial for future success.

Much of this socialization has a work ethic, success-oriented, "middle-class" flavor. It is important for students to learn self-discipline, to learn to persistently try their best, to keep trying no matter how hard the task. Although more "liberal" socializers might put more emphasis on encouraging individual expression, even skepticism, teachers see it as more appropriate to train students to be hard working, busy, polite, competitive, independent workers—and so on.

Teachers consider testing to be an important way of learning if students have learned the content, because, if they have, that is evidence that socialization efforts have been successful. The obvious corollary is that the instructional materials are used for socialization and that socialization is preemptive: Correcting behavior such as daydreaming or cheating takes precedence over conceptual learning.

The second aspect of socialization has to do with citizenship. Science teachers, as well as social studies teachers, advocate and try to inculcate "American values"—although all will not agree on what the values are. A major goal is to impart the attitudes that will make the students adjusted, participating citizens. Included are respect for the law and for the rights of others, and appreciation of the American political system. Contrary to the claims of some,[8] the CSSE investigators concluded that it would be "incorrect to sort teachers into two groups, one of which teaches good courses in science and one of which indoctrinates youngsters in the social customs and values of the community" (Ch. 16). All teachers, except the completely disillusioned or intimidated, indoctrinate—although in different degrees, with different tactics, and stressing different values.

The teachers' perception of their role in socialization fits, of course, the sociological and anthropological view that formal schooling functions in part to transmit and preserve the society's values. Recognition of the extent to which teachers view socialization as important—both for school success and citizenship—may help to explain why many curricular innovations have not been adopted. Critical thinking, inquiry, experience-based curricula may simply not be compatible with the socialization aims of the teachers called upon to use them.

Student Motivation. Along with teachers' acceptance of the textbook as source of knowledge, and their view of teacher as authoritative giver of assignments and preparer of students for later success, runs another strong finding about teachers: a major problem to them is the lack of student motivation. In the National Survey (Ch. 10), a little over fifty percent of the teachers reported lack of student interest in the subject matter to be a problem. Teachers at the various CSSE sites frequently mentioned motivation of students as a major problem. To some extent, this meant discipline—e.g., students interrupting class by visiting, arriving late, leaving without permission. But the concern is broader than student misbehavior. In contrast to lack of student interest, only twenty-eight percent of the social studies teachers indicated in the National Survey that difficulty in maintaining discipline was a problem. Lack of motivation in some schools even manifests itself in refusal by students to attend school.

Teachers are concerned that the "carrot and the stick" motivation of grades doesn't work anymore—if it ever did—except with bright, academically able students. High interest in the subject matter of course for its own sake makes a student seem unusual and may even result in alienation from peers. Particularly distressing to many teachers, in light of their textbook-socialization orientation, is what appears to be a recent increase in the unwillingness of students to accept authority, to accept textbook "truths," to do their assignments or even to believe that they are worth doing. The sense of frustration is summed up on one CSSE teacher's statement (Ch. 15), that:

> *It's almost as though we have to prove why we're here, why we're functioning. (They as much as say:) 'What makes you think you have anything of value to teach us?' You know, I get the feeling many times that I'm on the defensive as a teacher. It isn't enough that I stand up and say, 'This is your assignment.' I almost feel as though I have to prove it, to prove that there's value in doing it, other than the fact that I just want them to do it.*

Teachers who have tried to motivate students by trying to make their courses more "relevant" have often not found the results to be any better. Anticipating what a variety of youngsters will find of interest on any one day is no simple task; on the other hand, the students' view of what learnings might be useful to them in the future are often very limited.

Although the lack of interest and motivation seems to perplex teachers, we picked up no feeling that it moved teachers to examine the basic assumptions from which they teach. Teachers do not seem to see a relationship between their textbook/subject matter focus, passive student learning, and their uses of the curriculum for socialization and the motivation problem. Nor did we find any indication that teachers are concerned about the level of cognitive development that students might need to deal meaningfully with the abstract material of textbooks. This apparent lack of awareness and reflectiveness has implication for teacher preparation programs that bear attention by the profession.

The "Basics." Teachers, as well as administrators and parents, seem to be clear about one thing: the importance of the "basics"—arithmetic and, especially for social studies teachers, reading—as major determinants of learning. From reading some professional journals, one might get the impression that concern with basics such as reading is being forced on social studies teachers who are "really" concerned with more "fundamental basics," such as critical thinking for citizenship. Some teachers do consider skills that they teach, other than reading, to be "basic." But, as we have noted above, an overwhelming impression is that most social studies teachers see textbook content, not higher reasoning processes, as important. Obviously, teaching based on written materials must rely heavily on student reading. The cry, "back to basics," especially in regard to reading, is most frequently not viewed by social studies teachers as a threat, but as congruent with their recognition that reading is essential to other learning. Furthermore, reading tends to be seen as a prerequisite, not a skill that might be learned through involvement in other learning. Again, the allocation of time to the basics of reading and writing cuts into that for social studies at the elementary level. But the importance of the emphasis is supported by junior high and senior high teachers.

III. Divergent Views of Academicians, Curriculum Developers, and Teachers

What appears to be a different perspective on the "back to basics" movement is but one symptom of the generally discordant relationship between classroom teachers and university subject matter specialists. The interests and orientations of the two groups are different in ways that came through strikingly, particularly in the CSSE report. In fact, their views of what is important in social studies education are often so dissimilar that it is as if teachers and university social studies educators were dealing with two different worlds of schooling.

We have noted above the concerns of teachers with socialization, and with having students learn knowledge as it is presented in the textbook. Teachers also are anxious about classroom management, and use content to that end—for example, assigning extra homework to punish rule breakers or giving good grades for being quiet and working hard. As part of the ongoing system of schooling, their own teachers imbued those values and norms in them as students. And now they have returned to participate in and contribute to the functioning of a system they learned to take for granted. They desire the approval of other teachers, just as other teachers seek their approval. They do not want to look ineffective in the eyes of their principal, for that could have consequences more serious than social disapprobation—such as transfer to another, less desirable school in a big district. Students and parents are part of the school's social system, too, and teachers seek their respect and approval—just as all of us desire the approval of the important "others" in our lives. Most of these significant "others" for teachers share the same concerns for socialization, for orderly schools, for student knowledge as reflected in tests over textbook content (even the parents who found similar social studies classes to be boring when they were students), and for knowing the "basics" before going on to more advanced things such as conducting investigations and conceptualizing on one's own as a student.

The common complaint of teachers about "ivory tower" professors takes on particular meaning in light of these concerns of teachers. It is not just, or perhaps so much, that education professors don't know much about how to teach a particular subject matter area (as teachers often say); it appears to be more that the professors' concerns are with other styles, different ways of organizing curricula, distinctions between social science and social studies education, appropriate philosophies of history, and critiques of textbook pale in the face of the personal ques of textbook pale in the face of the personal concerns of teachers who must manage groups of students to fulfill system goals so as to survive (literally, in some schools) and gain the respect of students, other teachers, administrators, and parents. Teachers do not see an epistemological link between course content and maintaining classroom control that university professors do not comprehend or appreciate. It is simply that teachers need, or believe they need, to use content in certain ways to achieve their goals and university professors frequently fail to appreciate those goals or the techniques. From the teachers' point of view, professors are often unprepared to provide appropriate preservice training, inservice assistance, or new curricula.

In short, the teacher's beliefs and the demands of the school as a social system are largely incompatible with the norms of the university scholarship system and with the norms of teaching espoused by trainers of teachers. Teachers and professors of history and social science both value content. But the university professor usually sees the discipline's conclusions as the ends of learning and eschews the use of content for management and socialization purposes. The teachers and the professors assume, therefore, different outcomes from the study of the academic subject. At the same time, teachers' treatment of subject matter as a means to the major goal of socialization is viewed by social studies specialists as inappropriate and dysfunctional, a necessary evil at best. Of course, it is not that the social studies specialists or the history and social science professors are against socialization; they are just interested in socializing in different directions.

If this portrayal is correct, it makes understandable teachers' reluctance about, even hostility toward, efforts of university professors, even history and social science professors,* to assist them; and it helps explain why that "intelligentsia"—except through the textbooks they write—has little reforming effect on what happens in social studies classrooms, and why other teachers and parents do have an influence. Teachers may not often express their concerns clearly (and the specialists tend to reject them when they do), but they are clear about the sources to which they can turn to for help. Although the National Survey (Ch. 4) indicated that teachers do report that college courses are an important source of information about new curriculum materials, other teachers are the more frequently reported source. Inservice training, including summer institutes, is seen as most helpful, according to CSSE, when the emphasis is not on revamping the teacher's conceptualizations, but on talking with other teachers and sharing "bags of tricks" for classroom use.

Supervisory Personnel. The feeling of uselessness, even animosity, toward university professors is also often extended toward district supervisory personnel. For example, in the National Survey, about thirty percent of the teachers said they needed no help with learning new teaching methods or obtaining information about instructional materials, and slightly over forty percent indicated they did not receive adequate supervisory assistance in these areas. Part of the difficulty, according to CSSE, is that school support systems—inservice training and the resource personnel at the district level—are weak. Staffs are inadequate in number, with supervisors given many different responsibilities on top of having 200 or more teachers to work with. Much of the supervisor-teacher contact is through bulletins sent from the central office—about planning to be done by committees, about schedules, and about obligatory inservice sessions with outside consultants. Intentionally or not, indeed, central office personnel and teachers often seem to isolate themselves from each other.

The staffs are weak in the teachers' eyes in other ways. A basic reason that teachers tend to pay little heed to supervisors and their inservice programs is that they don't view these persons as informed about the realities of the classroom. Supervisors and consultants tend not to deal with the teacher's real and difficult teaching problems—such as keeping lessons going in the face of the inattention and disruptions of unmotivated children, adapting curricular materials to achieve socialization goals for which they had not been designed. It is not that teachers don't want help; rather it is that they want "good" help, assistance that is responsive to their teaching situation as they see it, for they believe that they are best equipped to know what their needs are. And the more graduate work the central office person has done, the more likely it is that his or her views of schooling will not be in accord with the teachers' view of the realities of the classroom. From the teacher's point of view, advanced graduate work can hardly be expected to make the supervisor more helpful when it involves learning beliefs and attitudes about pedagogy and content that are dissonant with the teachers' own views, and when, as the CSSE report notes, there is no theory of instruction available that deals with the diversity of uses to which teachers put subject matter in the actual classroom situation.

The Fate of Curriculum Projects. Appreciation for the viewpoint of teachers also can, as noted above, help explain the fate of the New Social Studies materials. A major purpose of federal funding for curriculum development was to provide districts and teachers with alternative offerings from which to choose. Although some debate the extent to which an adequate breadth of alternatives have been provided, certainly the goal has been met to a fair degree. But great numbers of districts and teachers have chosen not to use the new materials. "Sour grapes" does not seem a plausible explanation; there is no reason to believe that any great number of social studies teachers rejected the new curricula because they had not been involved in the curriculum development projects or training institutes. Unadopting teachers are generally not obstructionists. Instead, it is simply more appropriate to them to continue doing what they have done before—practices consistent with their own values and beliefs and those they perceive, probably accurately, to be those of their communities. The new materials just don't "fit."

Teachers judged the new materials as likely to work only in exceptional situations, with elite groups of students who had attained the basics and perhaps more important, proper self-discipline. They saw, or sensed, when they were aware of the new materials, the contradictions between the developers' purposes and their own—the emphasis in the new materials on content, on reasoning and inquiry, and, consequently, the different use of subject matter. Not only was the achievement of goals they thought important threatened by the materials, but their central classroom expectations (e.g., everyone quiet and working on the same assignment) and management techniques were challenged. Some of the support by teachers for the "back to basics" movement may even be interpreted as reaction to the demands of the curriculum reform attempts of the 1960s—the new topics and content organizations, and unusual teaching roles not only seemed difficult to carry out but flew in the face of the teachers' view of the needs of students and the school.

Realities. If this portrayal of dissonance between teachers, on the one hand, and professors, supervisors, and curriculum developers, on the other, suggests to the reader that our sympathies lie with the teachers, you are correct. Undoubtedly, some teachers are incompetent or unwilling to exert the effort necessary for good teaching. But reading the CSSE report has recalled our own days in precollege classrooms and reminded us of the difference between what is and what could be. Too often what we read, and hear, and propound ourselves in the educational literature and at professional meetings represents an ideal which may not, and perhaps should not, be attainable. The legitimacy of socialization goals, although understood by anthropologists and sociologists, has not been examined adequately by those concerned with formal conceptualizations of social studies education and used to set a realistic context for teacher education and curriculum development.

Moreover, it is not just the obligations of universal public education that have been given short shrift by curriculum developers and teacher educators, but the constraints as well. To change one's perspective from that of reformer of schooling and student learning to that of teacher confronted with managing/directing the instruction of several groups of secondary school students each day (or one group of elementary school youngsters for several hours)—all to be done in the context of particular school building, district, and community beliefs and values—raises serious questions about the limited intentions of teacher educators and curriculum developers. Theories and reform ideas meet hard realities. For example, consider the potential consternation of a teacher urged to use an inquiry approach to teach five or six large classes daily, each containing many students who do not want to be where they are and for whom that class is only one of their classroom experiences during the day and over the years. The demands of system maintenance—of classroom, the school, the district, and the society—it seems to us, have not been adequately addressed in schema for curriculum development and teacher education. Failure to address such primary concerns has been a consistent failure from the Progressive Education Movement in the early Twentieth Century to the competency-based teacher education movement of today. Reform to be effective, must be based on the recognition that teachers operate with a total system, which must be mobilized and revamped if individual teachers are to make striking modifications in their students' social studies experiences.

This discussion brings us back to the purpose of this paper: To share impressions of the three NSF-funded status studies of science education in large part to encourage others to mine the wealth of material there. It should be evident that we believe the reports to be "must" reading for social studies teacher educators, supervisors, curriculum developers, and researchers. But what about social studies teachers? Is there anything of interest and importance for them?

In terms of practical, helpful suggestions for teachers to deal with those very real, personal teaching problems to which we have referred, the reports have little to offer. But for all of the teachers who wonder in moments of quietness what it is all about, and whether their commitments and frustrations are shared by teachers beyond their own immediate school building, the CSSE case studies can be valuable reading. They offer the opportunity to share in the thinking, beliefs, practices of teachers from around the country, in teaching situations similar to and different from one's own, to judge the extent to which one's own perspectives are shared, to develop an increasingly conscious sense of oneself as a teacher in a bureaucratic, universal education system, to examine—and perhaps, to reaffirm—one's role in that system.

We do not propose that teachers read CSSE because it will revolutionize their teaching or make them more open to the perspectives of teacher educators and curriculum developers at variance with their own. To the contrary, we suggest that the case studies will often help social studies teachers see that their concerns are shared by other teachers and to sense the legitimacy of their classroom perspectives. Our point is not that the status quo should be reinforced, but that proposals for change can best be evaluated and implemented when those who must play a central role understand and value their own position. Teachers have too long been on the defensive against the "intelligentsia." If teachers and professors and curriculum developers can become more conscious of teachers' beliefs and values, and of the origin and functionality of those beliefs and values as an integral part of the socialization function of mass education, then the groundwork may be laid for more realistic, effective definition and solution of instructional problems.

Teacher education and curriculum development need not undermine the teacher's management position, or appear to teachers to do so. Many of the goals of the New Social Studies can be taught in ways that take into account the realities of the classroom. But some of those goals may have to be modified in light of the purposes and realities of public education; and social studies teachers may decide that their beliefs and values also need modification to confront their own concerns about student motivation and to satisfy educational goals they deem important. The consistent student reports that social studies is uninteresting and the teachers' own concern about motivating students to learn suggest, for example, the need to re-examine the assumptions underlying textbook-recitation teaching. At the same time, it would be naive at this point to advocate that the textbook be abandoned as a central instructional tool, or to argue that to do so would solve the problems of student motivation. Why the textbook has remained the central tool and how to utilize that form to achieve a wider range of educational goals are questions that have not been adequately addressed by social studies educators. Answers to both must take into account the social content of classroom teaching.

IV. Research

Elementary and secondary school teachers are not much aware of educational research. Nor are they much influenced by research findings, largely because the findings usually have little practical importance for the classroom. Instructional research in social studies education is aimed at such matters as the effects of different teaching methods, the characteristics of teachers, and the content of textbooks. How to handle the difficult problems of classroom management that teachers find pressing and how to accomplish the socialization goals which teachers believe are important have not been matters of interest to researchers. By contrast, behavior modification research seems to have impacted classrooms, especially those taught by special education teachers, because of its ready application to classroom management problems.

Even if social studies teachers were generally concerned with questions about how to teach students to be creative, independent thinkers, or how to sequence learning activities to achieve higher order cognitive and affective outcomes, the research literature would probably provide them little assistance in their efforts. The Review confirmed in great detail what commentators on research in social studies education have noted before: the research knowledge in the field is basically in disarray. There are few cumulative findings of either practical or theoretical significance. Most of the research (as in science education) is done by doctoral candidates and is not done from a theoretical base nor using a strategy designed or likely to build knowledge based on related, replicative studies. The conclusions in the Review are replete with indications of areas of interest to social studies educators (not necessarily elementary and secondary school teachers) in which there is a lack of studies, inclusive findings, or unexplained conflicting results. Syntheses of past research have not been particularly productive, either. The Review does suggest that syntheses of research on carefully delimited topics, relying on research beyond that in social studies education, might be productive. However, we have serious doubts that the research base is there, "waiting for someone to analyze and wring the meaning out of it."

This is not the place for an in-depth exploration of alternative research strategies and approaches. Social studies educators who are interested in such matters, though, should find the three reports to be provocative reading. One can hardly read the Review without being struck by the massive lack of cumulativeness of social studies education research. Reading the Review in the context of the CSSE report also drove home the crucial point mentioned above—the unresponsiveness of most social studies instructional research to the problems and interests of classroom teachers.

We also found ourselves drawn to the contrast between the National Survey—well designed and executed, but sterile in its remoteness from the classroom—and the richness of the CSSE approach. Survey research undoubtedly has its place as a means of gathering information, although it also certainly has been much overdone as a research form, especially for doctoral dissertations. But as a tool for determining the status of science education, in the sense of what is happening to students in science classrooms, the survey data seem to be a pale, remote representation when placed next to the CSSE ethnographic data. Ethnographic research minimizes prestructured expectations and questions. It relies for its data on field observers who are not aloof, detached empiricists, but involved, if analytical, participants in the setting of interest. The CSSE case studies vary in quality. But generally their personal vignettes and on-the-spot interpretations provide a strong feeling of reality that is impossible to capture through questionnaires and observational instruments. And the synthesis chapters in which the findings from the eleven case studies were integrated and discussed contribute to a "holistic" feeling for the teacher's classroom life that is impressive.

In recent years, several authors have commended ethnographic research methods to the educational research profession, and to social studies education researchers in particular. The CSSE report is, to our knowledge, the first major attempt to apply ethnography to research in social studies education, and it vindicates those advocates. We hope that there will be more studies from that perspective in the future.

It is important to remember, of course, that the CSSE case studies are carried out and synthesized by trained, experienced field observers. The project personnel were well aware of problems of methodology such as the differing frames of reference and the varying data-gathering styles brought to the sites by the various observer-participants. Moreover, eleven sites were studied—a time-consuming, expensive venture. Clearly university or school district researchers without ethnographic training or experience should be cautious so that efforts to capitalize on the potential of ethnography do not result in an adulterated paradigm and invalid findings. Equally important, it would be an error for doctoral candidates ill-trained in ethnography and without competent supervision to rush out to do limited field studies (limited in theoretical base and/or in number and/or representativeness of sites). The dangers of wasted research effort and no less with the ethnographic approach, and because so much relies on personal perceptiveness and insight, perhaps the dangers are greater.

We would not want anyone to take our affection for the ethnographic approach, as used for CSSE, to mean that we think other types of research should be abondoned. To the contrary, we are arguing for acceptance of the legitimacy of a greater variety of research approaches. Concurrently, more adequate conceptualizations of the research process are needed, taking into account strategies for knowledge-theory development. The development of research design paradigms appropriate to the schooling context and clarifying the choices among approaches depending on the problem and/or the stage of knowledge development is a major task awaiting those interested in promoting the productivity of instructional research in social studies. Of course, the questions are much broader and more difficult than when to use an ethnographic, or some other approach. They go to the heart of the meaning of science and its relevance and adaptability to the demands of building sound, systematic knowledge about instruction. Such matters deserve a great deal more consideration than can be given them here.

V. Conclusions

It seems wise, although probably unnecessary, to remind the reader once again that we are very much aware of the difficulties and dangers of presenting summaries and presentations based on such quantity and diversity of data as are available in the three NSF-funded reports on the status of science, mathematics, and social studies education. It is not just a matter of the validity of our interpretations, but of our conscious and unintentional selectiveness in deciding what to comment upon. The authors of the CSSE report note that a question was raised about their failure to elaborate on the preponderance of male teachers at the secondary level; but they indicated that that point had not surfaced soon enough as a salient problem in their interpretive frame of reference. Such question will undoubtedly be raised about this paper, too. For example, we have chosen not to deal with the question of articulation—either vertical, i.e., from course to course, or horizontal, i.e., from school to school. This may seem a strange oversight in light of the frequent concern with scope and sequence on the part of those who write about social studies education. The CSSE report (Ch. 13, 14, 19) does have some things to say about articulation—its frequent absence, the lack of teacher or parental concern about it, the possibility that it may not even be wise if done as specifically by individual districts. This one topic is illustrative of the variety of issues for which relevant data can be found in the reports, depending on the interests of the reader, though we may have chosen to emphasize other matters which took on salience for us in our reading and discussions.

It is also important to recall that the intended audience for this paper is not the National Science Foundation, but social studies educators. And the purpose of the paper is not to critique the National Survey, the Review, and CSSE studies. Rather, it is to summarize the reports and present interpretations of the status and need of social studies education to the extent possible in a brief chapter. In developing our impressions of social studies education from reading and discussing the reports; bias, as already noted, has probably been inevitable. In particular, our discussions of status will imply needs. Perhaps the obvious bears restatement, however: facts do not speak for themselves, and there is nothing in the data itself that dictates needs or points toward specific desired changes. Such conclusions depend on the value assumptions that one brings to the data. For example, we found the report to portray social studies education as dominated by textbook-recitation type teaching (although a variety of methods are being used). We consciously strived to avoid turning that generalization into a value judgment—especially the common one among professors that, *ipso facto*, social studies instruction is inadequate and attempts must be made to change it. We have alluded to the possible functionality of the socialization purposes for which teachers use content, and the textbook as the embodiment of subject matter learnings. We have pointed out the demands and the constraints of public universal education—including societal expectations and the reality that teachers face each day working with classes of youngsters who have varying goals and expectations, and many of who not only lack interest in the specific content of the course but in schooling in general. We have also mentioned that teachers are concerned about the lack of student motivation. We have noted, too, that we lack adequate answers to questions about the effects of textbook-centered instruction in social studies. And that the questions themselves call for more careful consideration of the legitimate socialization functions of the school as the formal education institution for the society.

So, our intent in portraying has not been to imply goodness or badness. Why things are as they are, and to what extent they are functional, are important unanswered questions. This line of inquiry suggests that educational research should undergo a significant shift in orientation. Discussions of the productivity of educational research have commonly been framed in terms of its influence in changing practice. Jackson and Kieslar[10] have expressed well the need to challenge that traditional perspective, referring to the narrowness in educational research because of

> *the almost total absorption with the goal of improving practice and discovering better techniques. We seldom ask whether educators might now be doing as well as can be done in many aspects of their endeavor. We might pay more attention to the possibility that educators may deserve and benefit greatly from some external confirmation of the appropriateness of much of what they are doing.*

Of course, the point is not to argue for the uncritical acceptance of current practices, but to suggest that more attention be given to research aimed at discovering and verifying their positive effects. Such research must rest on the careful examination of the assumptions underlying our evaluations of school practices. Moreover, the findings that result may challenge many of those assumptions.

Consideration of current instructional practice leads to some concluding comments on the importance of the teacher as the key to the experiences that students have in social studies. How teachers handle curricular decision-making and shape their classrooms might be affected by greater awareness on their part of their pivotal role not only in determining the curriculum for their students but, in the aggregate, shaping social studies education in the United States. As with any of us, we suspect that teachers are usually so close to, so enmeshed in, their own situations that it is difficult for them to "stand back" to analyze what is happening and set it in broader perspective. Reading the CSSE report in particular could help teachers gain insight into the power of the cumulative decision they and their colleagues make.

Moreover, the sense of the reality of the classroom for teachers that comes from reading the case studies could be invaluable for district supervisors who wish to understand teachers' concerns in order to work better with them, professors considering appropriate approaches to preservice and inservice teacher education, and curriculum developers who wish their developments to be used in the classroom. In each case, the case studies suggest hypotheses to be tested as a basis for more effective assistance to teachers.

The view of teachers as the key to student learning and the potential of the CSSE study for use in perspective-shaping and hypothesis-formulation also suggest, we believe, that teachers themselves should be more central figures in research in social studies education—but not only as "subjects." More carefully designed studies of teachers' beliefs, values, and expectations are needed as a basis for understanding what does and can happen in social studies classrooms. But teachers should not be treated exclusively as "subjects" in research studies. They should be partners in the research enterprise. They should be brought into studies as knowledgeable "informants"—in the positive sense of sources of otherwise unobtainable information about the realities that condition the use and effectiveness of teaching methods and materials. Equally important, teachers should be involved to a much greater extent in the process of defining needed research. Such a research partnership need not subvert researchers' interests in theory development—which have not borne much fruit to date; it could help to build linkages so that instructional research in social studies would have greater payoffs for school practice.

Teachers can tell others, and each other, much more about teaching than we have asked or allowed them to do. Teachers do, in particular, respect other teachers' insights into instructional problems. Professional mechanisms are needed for capitalizing on the validity of teacher knowledge for other teachers. Some of the CSSE case studies led us to think of the brief case reports in medical journals in which medical doctors describe their treatment of difficult or unusual cases. Those reports are somewhat akin to the Classroom Teacher's "Idea" Notebook that is a regular feature in *Social Education*. But the Notebook, like most "professional" efforts at assisting teachers, is curriculum-oriented; the classroom management and socialization concerns of social studies teachers tend not to get dealt with. On a much broader scale, attempts to assist teachers—whether on the part of the National Science Foundation, the U.S. Office of Education, or the NCSS Field Services Board—need to tap more explicitly both the concerns and the expertise of teachers.

Perhaps the most fitting way to end this paper is with our overall impression of social studies education in the 1970s. That impression is one of contrasts and contradictions. Amidst many impressions of change (especially when one reads the professional journals, hears the protests of parents in "innovative" districts, attends section meetings at the annual meetings of NCSS—i.e., views the "tip of the iceberg," so to speak), the three NSF-funded status studies indicated that there has been great stability in the social studies curriculum. For instance, there had been considerable publicity in recent years about New Social Studies (especially NSF) curriculum projects. Nevertheless, those who graduated from high school twenty years ago or more would, if they visited their local schools, typically find social studies classes to be similar to those they had experienced. Yet the perception of overall stability should not be allowed to mask significant changes that have occurred in some districts. Nor do we mean to avoid questions of limited perspective. Have there been changes not recognized by those of us close to the scene, in terms of both involvement and point in time? And, how does one judge the perceived stability against societal and professional needs for maintenance and continuity, as well as for critical social and professional inquiry? Such questions are an intimate part of the contrasts and contradictions in social studies education.

There also is much diversity and variety in what goes on in social studies classrooms, at the same time that there is much sameness. Individual teachers are free to do things differently, and what is expected of students differs somewhat from district to district and from teacher to teacher; but the same textbooks are used in a course "sequence" that varies little from location to location. The result is considerable uniformity across the country—a locally accepted nationwide curriculum—so that students face few problems on continuity in moving from district to district, no more so than moving from one school to another within a district. Yet, the day-by-day social studies experiences of youngsters often vary dramatically, even in adjacent classrooms.

To sum up, social studies education is not as good as some would claim, but not as bad as others would complain. Despite a lack of interest in, even an apathy towards, social studies (as well as school in general), most students find school a comfortable place to be. This may be in large part because, despite the disinclination of teachers to reckon with the apparent contradiction between their belief that **they** know what is good for students, what students need to know and how they learn best, and their prevailing concern for the lack of student motivation, teachers do like their students and are concerned about them personally as well as scholastically. Teachers do want to do a good job; they work hard under a great deal of pressure; apparently, only a few do not give a full measure of effort. So there are in the three NSF project reports reasons for optimism and confidence, mixed with what many will find to be reasons for dismay, even apprehension. Regardless of your stance and your reactions to our impressions, we believe that the reports of the three NSF-funded studies can be of use to you in constructing your own future in social studies education.

* * * *

To give readers an idea of the national distribution of the CSSE Sites and to help them identify case studies that might be of particular interest to them, brief descriptions of the sites from the CSSE report are listed below:

Chapter in Vol. I of CSSE Report	**Code Name**	**Description**
1	RIVER ACRES	Suburb of Houston
2	FALL RIVER	Small city in Colorado
3	ALTE	Suburb of a large Midwestern city
4	BRT	Consolidated district in rural Illinois
5	URBANVILLE	Metropolitan community of the Pacific Northwest
6	PINE CITY	Rural community in Alabama
7	WESTERN CITY	Small city in middle California
8	COLUMBUS	Columbus, Ohio, school district
9	ARCHIPOLIS	Eastern middle seaboard city
10	VORTEX	Small city in Pennsylvania
11	GREATER BOSTON	Urban section in metropolitan Boston

References

[1] In the rest of this paper, we use the term "social studies," rather than "social science education" or "social science/social studies education."

[2] Iris R. Weiss. *Report of the 1977 national survey of science, mathematics, and social studies education*. Report to the National Science Foundation on Contract No. C7619848. Center for Educational Research and Evaluation, Research Triangle Institute, March 1978. Available from: Superintendent of Documents, U.S. Government Printing Office (GPO), Washington, D.C. 20402, -038-000-00364-0, $6.50; National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield, VA 22151, -PB280192/AS, $15.00; Education Research Information Clearing House (ERIC), 4833 Rugby Avenue—Suite 303 Bethesda, MD 20014, -ED 152565, $1.16 microfiche, $32.81 paper.

[3] Stanley L. Helgeson, Patricia E. Blosser, and Robert W. Howe. *The status of pre-college science, mathematics, and social science education: 1955-1975. Volume I. Science education*. Report to the National Science Foundation of Contract No. C762067. Center for Science and Mathematics Education, The Ohio State University, 1977. Available from: GPO, (see footnote 1), -038-000-00326-3, $4.25.

Marilyn N. Suydam, Alan Osborne. *The status of pre-college science, mathematics, and social science education: 1955-1975. Volume II. Mathematics education*. Report to the National Science Foundation on Contract No. C7620627. Center for Science and Mathematics Education, The Ohio State University, 1977. Available from: GPO, -038-000-00371-2, $4.50.

Karen B. Wiley. *The status of pre-college science, mathematics, and social science education: 1955-1975. Volume III: Social science education*. Social Science Education Consortium, Inc., 1977. Report to the National Science Foundation on Contract No. C7620667. Available from: GPO, -038-000-00363-1, $6.25.

[4] Robert E. Stake and Jack A. Easley, Jr. *Case studies in science education*. Report to the National Science Foundation on Contract No. C7621134. Center for Instructional Research and Curriculum Evaluation and Committee on Culture and Cognition, University of Illinois at Urbana-Champaign, January 1978. Case studies: Terry Denny, *Some still do: RIVER ACRES, Texas*; Mary Lee Smith, *Teaching and science education in FALL RIVER*: Louis M. Smith, *Science education in the ALTE schools*; Alan Peshkin, *Schooling-at BRT; A rural case study*; Wayne W. Welch; *Science education in URBANVILLE: A case study*; Rob Walker, *Case studies in science education: PINE CITY*; Rodolfo G. Serrano, *The status of science, mathematics, and social science in WESTERN CITY, USA*; James R. Sanders and Daniel L. Stufflebeam, *School without schools: COLUMBUS, Ohio's educational response to the energy crisis of 1977*; Jacquetta Hill-Burnett, *Science in the schools of an eastern middle seaboard city*. Gordon Hoke, *VORTEX as harbinger*; Rob Walker, *Case studies in science education: GREATER BOSTON*. Available from: GPO, *Volume I: The case reports*, -038-000-00377-1, $7.25, *Volume II: Design, overview and general findings*, -038-000-00376-3, $6.50, NTIS, total set, -PB282840, $76.75. Also available from NTIS, the 16-booklet set from which the two GPO volumes were assembled. Prices available on request.

[5] The NSF-funded reports do not deal with the status of student learning from these experiences as, for example, the National Assessment of Education Progress is intended to do. Chapter 15 of the CSSE report discusses pedagogical issues related to learning, and Section 3 of the Review speaks to the outcomes of social studies instruction.

[6] The percentage of social studies teachers who report (National Survey, Ch. 4) attending NSF-sponsored institutes, workshops, and conferences is low—4% for K-3, 8% for 4-6, 4% for 7-9, and 5% for 10-12 grade teachers. By contrast, the corresponding percentages for science teachers are 2, 23, 32, and 47.

[7] The higher percentages come from studies cited in the Review. Because of limited samples and the small rates of return from respondents for most of those studies, we regard the results as probably inflated. Even the self-reports of the National Survey may be inflated by the tendency of survey respondents to give socially desirable answers.

[8] For example, Robert D. Barr, James L. Barth, and S. Samuel Shermis. *Defining the social studies*. Bulletin 51. Washington, D.C.: The National Council for the Social Studies, 1977.

[9] We have discussed earlier the usually implicit and unplanned dominance of historians and social scientists as role models for social studies teachers. Here we are referring to explicit attempts to intervene and influence school practices.

[10] Phillip Jackson and Sara B. Kieslar. Fundamental research and education. *Educational Research*, 1977 (Sept.), 6(8), 13-18.

Mathematics Teaching Today: Perspectives from Three National Surveys

James T. Fey[1]

Introduction

If teachers, parents, and students in your community were asked to identify the strengths and weakness in school mathematics today, would the resulting discussion yield sentiments like those in the following quotations?

Would you hear secondary mathematics teachers saying,

*We offer excellent training for the college-bound... For all students we offer the discipline that comes from a rigorous regimen of study. (3-2:11)**

We've found that traditional methods of instruction work. This is the way it was taught to us in high school and the way it was taught in college and the way it works for us... I don't think kids can handle inquiry... They just don't have the background or sophistication. (3-2:11)

The problem most common to us teachers is that we can't keep real algebra exciting for the students. When the students ask, 'How am I going to use this stuff?' our usual answer is foggy. The only answer is in higher mathematics. (3-1:69)

What is lacking in the textbook is applied mathematics. Even the average text goes into properties. A kid just does not have to know 'commutative' and 'distributive' to function in the world. (3-1:68)

Hard and boring. That's why I got into math. Trying to figure out how to make it not boring. I have been disillusioned. It is a drag. (3-1:106)

Reading will panic most of our kids in math, even some of the (best). If two sentences are given to direct students in a mathematics problem, not more than two of thirty can go directly to the work. I don't have time to teach statement problems. We spend too much time on theory and not enough on statement problems in this curriculum. So we are losing a chance to develop a child's reasoning ability. Statement problems are the key. (3-1:71)

Would your teaching colleagues in science complain about your students?

I can see the results of the new math on all the students I've had here. As sophomores, they don't know how to do long division (and) most don't know how to figure up percentages. It really shocks me ... they're lost to science as far as math is concerned. (3-4:9)

Would elementary school teachers echo those complaints about recent changes in curricula and materials?

Modern mathematics? I dislike it... (The text) shows three ways when one will do. The brass tacks are learning addition and subtraction. That's it. (3-1:31)

This book has too much esoteric garbage in it. It is simply too hard. The geometry is silly (to try and teach) even for our best third graders. So we all skip it. (3-1:33)

We are fortunate not to have gone way out for the new math. We have stuck to the basics throughout it all and the results that are coming in show we were right. (3-1:33)

Would parents express the following kind of support for current programs?

My kids understand the basic number system much better than I ever did at their age... They know, for instance, what multiplication is, rather than just knowing some tables by heart. In the long run I'm sure this will be a big advantage to them, especially when they come to take algebra or calculus. (3-6:52)

---

[1] On behalf of an *ad hoc* NCTM committee the members of which were James T. Fey, Jeremy Kilpatrick, Catherine Tobin, and Harry Tunis.

*The reference scheme is explained at the end of the paper. The basic pattern is (Source-Chapter: Page).

These reports appeared originally respectively in *The Mathematics Teacher*, Volume 72, Number 7, October 1979, and in *The Arithmetic Teacher*, Volume 27, Number 2, October 1979.

What might students say? Would they repeat the following thoughts?

I'm in level three. That means they won't teach us algebra. They will only teach us what we have already had. Math is learning over and over what you already know and keep forgetting. (3-1:72)

I haven't heard anyone, anyone except a mathematics teacher say that math is great. You gotta know how to figure your income tax, how to get money from banks, how to buy or sell stuff, know the stock market and maybe a couple other things and that is it. (3-1:110)

If these comments reflect the situation you meet in planning and teaching mathematics, your concerns are shared by many other mathematics teachers K-12 across the United States. Each quotation was taken from a fascinating series of studies completed recently under the auspices of the National Science Foundation (NSF).

For several years, debate over goals, practices, and effectiveness of science and mathematics education has swirled throughout public and professional education meetings and publications. Much of the controversy has been sparked by disagreement over the value and impact of curricular and instructional innovations whose development was supported heavily by the federal government through NSF, the U.S. Office of Education (USOE) and the National Institute of Education (NIE). The NSF contribution alone reached a high of $40 million per year for teacher education and $20 million per year for curriculum development in 1968.

To assess the impact of those efforts and to identify some activities likely to yield valuable improvements in education during the next ten years, NSF commissioned three extensive studies of current and recent practices and basic needs in science, mathematics, and social science. The first study in each area was to be a comprehensive critical review of the literature on curriculum, instruction, evaluation, and teacher education from 1955 to 1975. The review for mathematics was conducted by Marilyn Suydam and Alan Osborne at Ohio State University. The second study was a collection of surveys directed at teachers, administrators, parents, and students in grades K-12. The surveys were directed by Iris Weiss at the Research Triangle Institute (RTI). The third study was a collection of case studies in selected schools and districts, studies carried out by educators with various observational and analytic approaches to the investigation of schools. These case studies, coordinated by Robert Stake and Jack Easley at the University of Illinois, also employed a small scale questionnaire survey to confirm generalizations from the several case study sites. The results of these diverse attempts to describe and explain school mathematics today have been published in an imposing collection of six volumes. The following report is an attempt to synthesize the findings and to highlight the most provocative implications. The report will describe findings of the literature review and the RTI survey, using selections from the case studies to elaborate on the picture those data present.

The report was prepared by an ad hoc NCTM committee including:

James Fey, University of Maryland
Jeremy Kilpatrick, University of Georgia
Catherine Tobin, Lexington,
Massachusetts Public Schools
Harry Tunis, NCTM Staff

Work of this group was supported by a contract from the National Science Foundation.

Course Content and Enrollments

Among the most prominent goals of NSF curriculum efforts were major changes in the content and sequence of school mathematics, science, and social studies programs. Particularly in mathematics, these attempts at innovation have been widely criticized. When the 1975 National Advisory Committee on Mathematics Education (NACOME) attempted to weigh the pros and cons of recent changes, they seriously questioned the extent to which 'new math' ever became a part of the program in most schools. That committee called for careful study of the curriculum in common use at various grade levels. Among the three current studies, the RTI survey provides most direct and objective information.

Questionnaires were sent to 192 state supervisory personnel, 488 school system superintendents, 2634 district supervisors, 1411 building principals, and 6378 classroom teachers at all grade levels. Response rates ranged between 72 percent and 90 percent. Building principals were asked to provide lists of the courses offered in their school and the enrollment in each course. The data are given in Table 1-1 where 1976-77 figures are compared with figures from another national survey of 1972-73. While it is risky to compare numbers from surveys using different methodologies, there are some very large differences in particular courses and differences in the distribution of enrollments among courses that suggest interesting conjectures about trends in school mathematics curricula.

Table 1-1. Course Enrollments in Secondary Mathematics for 1972-73 and 1976-77 (In Thousands)

	1972-73*	1976-77**
General Mathematics 9-12 . . .	2417	2563
Business Mathematics 9-12 . . .	392	609
Elementary Algebra	2052	2825
Advanced Algebra	1808	1317
Geometry	1506	1900
Trigonometry	171	460
Probability/Statistics	25	39
Computer Mathematics	63	153
Advanced Senior Mathematics	259	225
Calculus	55	105

*Source: (4:10)
**Source: (1:59)

The data of Table 1-1 confirm some of the commonly expressed impressions about enrollment patterns: the increase in business mathematics probably reflects increased attention to consumer and career competence skills; the increase in elementary algebra may reflect a change in the entrance requirements for algebra and an increase in the number of students who are being guided into the two-year version of this course (and thus effectively counted twice by the survey); the large jump in reported trigonometry enrollments suggests that the marriage of advanced algebra and trigonometry attempted during the 1960s has proven unsatisfactory for many schools, and trigonometry is returning as an independent one-semester course; the modest growth in probability and statistics enrollments suggests that, despite strong support for inclusion in the curriculum, these topics have not become a major option to either algebra, geometry, or general mathematics.

Some of the enrollment changes are more surprising. While many mathematics educators express grave concern about the future of school geometry, enrollment in that course shows no sign of decline. The rapid growth of computer mathematics and calculus enrollments suggest that many students are gaining strong high school preparation; but paradoxically, the number of students taking advanced algebra and advanced senior mathematics seems to have declined over the past five years. It appears that while some students are getting more and more advanced mathematical experiences, there is a large body of less able or less ambitious students who are electing to stop their high school mathematics preparation after geometry. The urgent question of the 1960s as to whether calculus should be taught in high school seems to have been resolved.

Course offerings and enrollments give a broad indication of the trends in mathematics being studied by various student populations, but a single title can cover widely varying syllabi. Many have argued that in mathematics the textbook dictates the course, and teachers were asked to indicate which of the most common school texts were being used in their courses. The market for grades 7 and 8 seems fairly evenly divided among a variety of textbook series. Many different texts series are used in high school elementary algebra, geometry, and advanced algebra, but the Houghton-Mifflin texts are clearly most common. (1:90) What remains unclear is the emphasis that classroom teachers place on the various topics in those texts.

Neither the survey nor the case studies indicate, for instance, whether teachers routinely skip the probability or trigonometry chapters in elementary algebra texts or include geometry as a major component of seventh and eighth grade instruction. The emphasis given to proof in any course is unclear. Scattered teacher remarks to the case study investigators suggest that there is a pronounced "back-to-basics" trend in curricular emphasis. The "basics" are usually interpreted as arithmetic and manipulative algebra, but the various studies yield no quantitative sense of this movement.

One of the frequently reiterated explanations for the apparent troubles of mathematics education in secondary school is a widespread decline in student regard for any mathematics that goes beyond the basics. To some extent this is reflected in lower enrollments for advanced algebra; it also appears in the formal requirements for high school graduation. Over 56 percent of districts responding to the survey indicated that only one or no mathematics courses are required for graduation, while only 7 percent of those districts make such low requirements in social studies. (1:25) Mathematics (and reading) appears to be a high priority in elementary school, where social studies is perceived as much less important; but the tables turn in secondary education. It is surprising that mathematics teachers so frequently voice concern over the limited reading skills of their students when this is the focus of elementary schooling. Perhaps skills for reading mathematics need to be specifically taught or possibly reading difficulties are being used to explain poor mathematical skills.

The National Science Foundation is obviously interested in the extent to which materials developed under their support have influenced or are being used in current school programs. The survey data indicate that prior to 1976-77 about 30 percent of the sampled districts had used one or more of the federally sponsored innovative curricula in mathematics, but only 9 percent were still using those materials in 1976-77. (1:79) While many of the innovative ideas of the School Mathematics Study Group (SMSG) and other early mathematics projects have undoubtedly made their way into commercial texts (5), survey data suggest that in science the original project materials have remained in widespread use much longer. This pattern raises the question of what mathematics developers have done differently and why.

Patterns of Instructional Style

Over the past 20 years the course content proposals of "new math" curriculum projects and advisory groups have received prominent support and professional scrutiny. But nearly every such syllabus innovation was accompanied by recommendations for change in teaching style. Mathematics teachers have been urged to implement discovery learning, mathematics laboratory activities with hands on learning, individualized instruction, multimedia instruction, and many other promising pedagogical strategies. However, as is the case with attempted changes in the content of school mathematics, the NSF studies provide reason to question the extent to which any of these proposals for innovative pedagogy have influenced predominant instructional patterns.

Several parts of the RTI questionnaire asked teachers to describe mathematics instruction in their classes—amount of time available, allocation of that time to various activities (lecture, discussion, small groups, and so on), use of media, class size, and testing. Data on average class length were sought only for elementary grades where, as Table 1-2 shows, mathematics fares very well in comparison with science and social studies.

Table 1-2. Average Number of Minutes Per Day Devoted to Mathematics, Science, and Social Studies in Elementary School*

	Grade Range	
	K-3	4-6
Mathematics	38	444
Science	19	35
Social Studies	22	40

*Source: (1:50)

This and other related data support the common impression that attention to reading and then arithmetic are high priorities in elementary school. However, other studies that have relied on trained observers rather than teacher self-reports suggest that the actual time spent on mathematics may be less than what is given here. (2:53)

With respect to class size, another variable that teachers commonly judge to be an important influence on their effectiveness, mathematics also fares well in relation to science and social studies. Table 1-3 shows the average class sizes reported by teachers in the three subject areas. In grades 7 to 9, average class size in mathematics is markedly lower than the other two subjects, though many would argue that it is not enough lower to make an educationally significant effect.

Table 1-3. Average Class Size in Mathematics, Science and Social Studies at Four Grade Range Levels*

	Grade Range			
	K-3	4-6	7-9	10-12
Mathematics	24.2	27.7	26.7	23.6
Science	23.5	26.6	30.6	22.8
Social Studies	24.1	28.2	29.8	27.2

*Source: (1:67)

The common forms of organization for student groups in mathematics instruction are indicated by Table 1-4. Within these groupings the frequency of various specific instructional strategies is given by Table 1-5. The data given there are averages over grades 7 to 12, but the breakdowns by grade range are surprisingly similar. The most noticeable trends from kindergarten to senior high school are steady increase in the frequency of tests and quizzes and steady decrease in the use of manipulatives and student involvement techniques.

Table 1-4. Percent of Class Time in Various Organizational Formats, Mathematics K-12*

	Grade Range			
	K-3	4-6	7-9	10-12
Entire Class as a Group	36	38	45	54
Small Groups	29	25	17	22
Students Working Individually	36	38	38	24

*Source: (1:111)

Despite the difficulty of knowing what teachers understood by the terms "lecture," "discussion," and "individual assignment," the profile of mathematics classes emerging from the survey data is a pattern in which extensive teacher directed explanation and questioning is followed by student seatwork on paper and pencil assignments. This pattern has been observed in many other recent studies of classroom activity (2:76) including several in which actual classroom observations, rather than teacher self-reports, were the source of data.

The NSF case studies paint a similar, but even more pedestrian picture of day-to-day activity in mathematics classes at all grade levels. The following remarks from a case study by Wayne Welch outline conclusions about mathematics teaching that were repeated by nearly every other observer.

In all math classes I visited, the sequence of activities was the same. First, answers were given for the previous day's assignment. The more difficult problems were worked by the teacher or a student at the chalkboard. A brief explanation, sometimes none at all, was given of the new material, and problems were

Table 1-5. Frequency of Instructional Techniques in Grade 7-12 Mathematics Classes*

	Percent of Classes			
	Never	Less Than Once a Week	At Least Once a Week	Just About Daily
Lecture	4	6	22	67
Discussion	4	8	19	69
Student reports/projects	44	37	16	3
Library work	75	23	1	0
Students at chalkboard	8	33	34	25
Individual assignments	12	19	11	57
Students using manipulatives	36	45	12	6
Televised instruction	93	6	1	0
Programmed instruction	83	13	1	2
Computer assisted instruction	88	8	3	1
Tests or quizzes	1	22	73	3
Contracts	88	9	1	2
Simulations	91	8	1	0
Field trips	87	13	0	0
Guest speakers	83	17	0	0
Teacher demonstrations	15	25	26	32

*Source: (1:B-58,59)

assigned for the next day. The remainder of the class was devoted to working on the homework while the teacher moved about the room answering questions. The most noticeable thing about math classes was the repetition of this routine.

Another observer in the same school system added,

A general comment about math classes is that they were dull. Science was perceived as being more fun ... I got the impression many students looked forward to science but no one seemed to look forward to math. (3-5:29)

Certainly, the mathematics teaching these observers saw embodied none of the spirit of inquiry, laboratory exploration, or individualization that has been so strongly urged by a variety of experts. But as Welch goes on to indicate, "Although it seemed boring to me, students and teachers seemed comfortable with it. Apparently it fulfills student expectations and provides the students opportunity for closure." (3-5:6) Commenting on the same phenomenon in another setting, case study observer Louis Smith recalled remarks of Hoetker and Ahlbrand.

If the recitation is a poor pedagogical method, as most teacher educators long have believed, why have they not been able to deter teachers from using it?

Or, is it not possible that the practicing teachers are right and the professors unrealistic, and that the recitation—for some reason—is the best pedagogical method? Or the only practicable one for most teachers. (6:163)

One could comfortably accept this latter explanation of predominant teaching styles and conclude that teaching, as it is now commonly practiced in mathematics classes, is about as effective as one can reasonably expect. However, the case studies and the survey produced frequent comments that students find study of mathematics boring and teachers find motivation of students to learn mathematics one of the most difficult problems they face. Furthermore, when teachers were asked what aspects of their jobs they most needed help with, at all levels they mentioned learning new teaching methods and implementing discovery/inquiry approaches. (1:B-105, 108, 111, 114)

The Suydam and Osborne review of recent research and expository literature offers little immediate hope that instructional research will yield new ideas or convincing support for any existing strategy or technique. There is no consistent pattern of results favoring recitation, discovery, small group, or individualized approaches in mathematics teaching; there is no demonstrably superior way to identify the knowledge, experiences, or personal traits of people who will be consistently effective teachers. There are certainly effective teachers of mathematics, teachers whose students enjoy and learn mathematics. But at the present time, such effectiveness appears to be the result of classroom activity that is an idiosyncratic product of a constantly changing interaction among the teacher, the student, and the mathematics being taught.

Teacher Abilities, Attitudes, and Beliefs

One of the clearest themes running throughout the reports of case study observers was the absolutely crucial role of classroom teachers in determining the character and effectiveness of science and mathematics education. As case study author Rob Walker noted, "Any observer cannot fail to be impressed by the fact that the resources tied up in teaching here are almost entirely human resources." (3-6:23) Louis Smith noted that when he sought generalizations about education, "administrators, board members, teachers, pupils always ended up talking about individual teachers." (3-3:112)

The limits of teachers' knowledge about mathematics or about ways that young people learn place predictable limits on what the teacher can offer and accomplish in the classroom. The teachers' beliefs about the nature of mathematics and the important goals of schooling are more subtle but equally important influences in their impact on students. The RTI survey and the case studies provide further insight into the status of mathematics education by analysis of teacher abilities, attitudes, and beliefs.

Secondary mathematics teachers currently average more than 12 years of teaching experience, half hold a degree beyond the bachelors degree, and about 40 percent were taking a course for college credit in 1976-77. In the junior high school grades, 54 percent of mathematics teachers are men, and in senior high school 68 percent are men. Nearly all mathematics classes are taught by teachers for whom mathematics is their only subject area of responsibility, and an overwhelming number of those teachers feel adequately qualified to carry out their teaching assignments. (1:137-145)

When teachers in grades 7 to 12 were asked to specify areas in which they would like assistance, they mentioned most often the topics given in Table 1-6. The needs expressed by mathematics teachers are remarkably similar to those of science and social studies teachers.

Table 1-6. Percent of Mathematics Teachers Expressing Needs for Assistance in Grades 7-9 and 10-12*

	7-9	10-12
Learning new teaching methods	40	42
Information on instructional materials	37	41
Implementing discovery/ inquiry methods	27	35
Using manipulative materials	33	35
Working with small groups	38	28
Articulation across grade levels	33	33

*Source: (1:B-111,114)

When these same teachers were asked to rate the seriousness of various potential problems, they consistently stressed lack of materials for individualizing instruction, lack of student interest in the subject, inadequate student reading abilities, and class sizes too large. Eighty percent said that low student interest is a problem and 90 percent said that inadequate reading abilities are a problem. (1:B-126)

These survey data give a sketchy quantitative outline of secondary mathematics teachers' backgrounds and concerns, but they only begin to tell the story of teacher attitudes and beliefs that emerges from consistent findings in the case study interviews. As teachers talked to the case study observers about their personal goals and methods in teaching, they confirmed some popular impressions of where mathematics teaching is headed, and they offered valuable insight to those who seek change in the present content, emphases, and processes of school mathematics.

On Basics—If, as public and professional discussions of education suggest, mathematics curriculum and instruction are going back to the basics, it appears that no one could be happier about the movement than the mathematics teachers themselves. With near perfect regularity, teachers at all grade levels told the case study observers that they applaud the return to traditional content, instructional methods, and higher standards of student performance.

Though there seldom is complete agreement on just what mathematical ideas are basic, the common factor is usually manipulative facility in arithmetic and algebra. Teachers said:

It is old fashioned and super to expect every first grader to have rapid memory of basic facts to ten. (3-1:29)

I wish they were almost taught no theory down there. Back to basics. That means delaying teaching of theory. (3-1:102)

The most frequently mentioned features of "back to basics" pedagogy are drill, repetition, and hard work.

I dislike our book, not enough drill, it's modern math. We adopted a new book ... it has more drill, more basics and I'll like it. (3-1:31)

I am using the rote method pretty much because (they) have found out that with a three level you can spend all hour trying to get them to understand (and they can't). (3-1:47)

The case study observers found that many teachers think too much emphasis has recently been placed on discovery learning, hands-on demonstrations, field study, and contemporary topics, and that time spent on them did not serve the learner well further along in school. (3-15:4) One teacher expressed the current mood well.

I am a very traditional teacher. I use chalkboard, a textbook, and handouts. (3-1:104)

Another very common ingredient of a basics philosophy is belief that mastery of certain skills is an essential prerequisite for concept learning and creativity.

The study of mathematics takes levels of maturity. You have to take step one before you can take step two. There is a definite hierarchy of material. You can't hope to be creative until you've mastered the basic program of studies. (3-2:11)

No algebra should be taught in junior high. Fortunately, nature is on my side and very little algebra can be taught in junior high. (3-1:102)

In the questionnaire follow-up to the case studies, 74 percent of the senior high school mathematics teachers felt that basic skills of reading and mathematics should be taught first and other things later. (3-18:54) Further, they agreed that setting minimum proficiency levels for advancement in school was necessary—a concern echoed by many teachers who are upset by perceived lax standards of student performance in general. Over 90 percent of junior high school teachers surveyed in the case study follow-up felt that students have been promoted without knowing basic mathematics. (3-18:62) Their specific comments were harsh.

As long as you run a school on a 'no child can flunk' basis, all kinds of deceitful grading practices will occur. (3-1:103)

Then we got into the madness where everybody had to have algebra ... So to get them in college we started giving higher grades and creating algebra courses that weren't and aren't algebra. We now have arrived at a curriculum that produces A and B algebra students that get crushed in college mathematics. (3-1:102)

On the Nature of Mathematics—Teacher judgments about basic objectives in mathematics undoubtedly reflect underlying beliefs about the nature and value of mathematics as a discipline. Several case study observers asked teachers to explain what they saw as the big ideas in mathematics. From elementary teachers the most common response was that mathematics is a collection of rules and procedures to be learned to a level of near mechanical proficiency. There was very little talk of the eventual use of this skill in any setting other than the next mathematics class. Secondary school mathematics teachers also seemed to feel this emphasis on algorithmic performance, but they were decidedly more bothered by the apparent hollow victory in achieving such a goal. One highly regarded teacher commented on the problem as follows:

There is abundant evidence to show that we are encouraging superficial learning in some of our (best students). Sure, they do well on the tests. Our materials on hand encourage this. The algebra book, for instance, is pure abstraction. The really good memorizer can go right through and not really have it at all. (3-1:68)

A colleague of this teacher went on to express the common concern that there is no practical value in algebra other than as preparation for higher mathematics.

The weakness in connections between mathematics and its domain of application has been frequently criticized over the past ten years. But the problem remains. Perhaps the difficulty is as much one of traditional expectations as it is one of curriculum development. We mentioned earlier that students seem to expect emphasis on facts and memorization in mathematics, along with the neat closure that comes from a discipline with well defined procedures and "right" answers. In one science class a site visitor suggested to students that they might find D'Arcy Thompson's book on *Growth and Form* an interesting guide to modeling of scientific observations by mathematics. The observer commented, however, that it was clear from the student responses that this was not regarded as mathematics. (3-13:25) The same narrow conception of disciplines seems to plague science as well. In a summary of science observations is the conclusion,

As seen by most people in the schools, science education has no more alliance with mathematics education and social studies education than it has with English education ... With a few exceptions, primarily in environmental education, there were essentially no interdisciplinary efforts in the sites we studied. (3-13:17-18)

When really pressed to find virtue in the study of mathematics, most teachers responded with variations on the familiar mental discipline argument.

Eighty percent of what I teach my level three algebra class cannot be used by 90 percent of the kids. The benefit (only) is to get into college. I can teach them to think logically about real problems in their lives today. (3-1:111)

Mathematics can teach the student how to think logically and that process can carry over to anything. To be able to start with a set of facts and reason through to a conclusion is a powerful skill to have. (3-1:112)

These teachers spoke for many others who reiterated the value of learning to think logically, to solve problems, but most of all to work hard. The case study follow-up survey found that 50 percent of senior high school mathematics teachers found virtue in the "new math" effort to put greater emphasis on formal logic. (3-18:34)

The students seem to sense this same underlying objective in studying mathematics, though they express somewhat more cynical regard for the goal. One observer found that students felt they needed mathematics as future citizens, even though they had found no environmental application for what they were studying. These students were, "hard pressed to defend a need for math—except that it was a sometimes useful proof that they were not escaping from the hard reality of school." (3-13:25)

On Teaching as a Job—The quality of mathematics teaching in schools today is certainly influenced by the knowledge and beliefs of teachers about mathematics and young people. But it is also certainly affected by the broader school and social context, within which mathematics education is only one of many activities and focuses of concern. While many teachers report satisfaction with the tasks they encounter daily and their effectiveness in meeting those challenges, many others are clearly concerned in ways expressed by a high school science teacher.

I've had a lot of spark taken out of me in the last two years. We hear administrators talking about meeting the needs of students—individualization. But we never get time off to develop these things or the financial support... I've talked to them about getting materials and they say that materials aren't as important as the student-teacher relationship. But I find it very difficult to stand up and play Johnny Carson everyday. The kids don't want to hear lectures, they want to do things.

I always thought that the main goal of education was teaching kids, now I find out that the main goal is management. (3-2:9)

Mathematics teachers also talk of going stale, of burning out. Louis Smith noticed this so frequently that he was led to characterize the condition as a mix of:

Flatness, a lack of vitality, a seeming lack of interest in the curriculum by both the teacher and the children, a lack of creativity and curricular risk taking, a negativism toward the children—they're spoiled, they don't care, they don't try—and sometimes a negativism toward colleagues, administrators, and college and university training programs (often decades ago). (3-3:84)

His suggested remedy was a community center for analysis of teaching and teacher sabbatical activities that would give teachers a chance to reflect, to recharge their knowledge and enthusiasm for instruction.

One very fundamental factor in the lives of teachers that seems to lead to their loss of enthusiasm and spirit of innovation is the isolation of a teacher's work in the classroom. In one sense this role as the sole adult in a sea of young people offers tremendous freedom and impressive responsibility. But on the other hand, it induces the separation of the world in school and the world outside of school that is seen by so many teachers and students to be a serious problem in education today. Case study observer Mary Lee Smith noticed several teachers who had maintained contact and identity with scientific and professional communities beyond the school, who had "kept open a window on the larger world of ideas." But she added, "Most teachers have only a mirror that reflects the values and ideas already dominant in the public schools." (3-2:18)

A growing militancy among teachers and resistance to emerging bureaucratization of schools was evident in comments of many other teachers. Teachers spoke of "us and them" meaning teachers and administrators. One teacher spoke bitingly about the impact of accountability:

We need to be working with teachers, not checking on them... Education is generally a negative enterprise toward children, toward teachers. It is a highly structured reward structure which emphasizes the negative. Those who get rewarded are those who make the fewest mistakes. (3-1:8)

and another expressed a sense of powerlessness.

There is no way to motivate a certain number of kids. They put forth absolutely no effort. I will not be held accountable for teaching an unteachable student ... Why is accountability the teacher's responsibility? Why is it always my job to solve every problem a child manifests in school? I am not in charge of the math program. So how can I be accountable for it? (3-1:8)

Despite the frequent complaints and identification of problems that (while not always new) need attention by those concerned with school mathematics, the mood of teachers that filters out of the case studies is captured well by Robert Stake:

They saw themselves in a serious, not very exciting business; the business of education. They saw themselves as pretty good businessmen, wishing that times would change for the better, but confident that they could deliver on their promises and pretty well satisfied that there is not really a better way to run the shop. (3-5:25)

This picture of mathematics teachers today, combined with the earlier profiles of curriculum and instruction in mathematics, shows the realities with which any attempted change in mathematics education must deal.

Changing School Mathematics

Most formal and informal indicators of educational activity suggest that the last several years have seen the close of a twenty year period in mathematics education that was characterized by numerous and striking proposals for change in the content and method of instruction. The current mood, as reflected in the NSF studies, is a search for stability, choosing from among topics and techniques with which teachers have long experience and comfortable familiarity.

Regardless of one's judgment about the proposed and actual changes in recent years, reflection on activities of the era is a rich source of insight into the decision-making structure of schools. Since the National Science Foundation programs clearly sought change in curriculum and instruction of school mathematics, all three status studies looked at the mechanisms of change in schools. They asked, "What are the channels that communicate information and influence classroom practice? What are the conditions that enable or block attempted innovations?"

Synthesizing a variety of different explanations for the rise and fall of 'new math', Suydam and Osborne suggest the following conjectures about change in mathematics education:

1. Educational policy is frequently determined without collecting enough information to allow the process to be rational.
2. Educational policy is frequently constructed without using information that is readily available.
3. The point at which values enter into policy formation, and the effects of the differences in the values held by various groups concerned with the schools, is frequently not recognized in determining the priorities within educational policy. (2:219)

Suydam and Osborne cite many instances in which decisions are made in absence of or ignorance of crucial factual information. But they argue that conflict of differing values and beliefs is the most critical problem in changing educational practice. They argue that policymaking operates at two levels, one incorporating professional judgments based on information and another that is political and reactive to the prevailing societal attitudes and values. Their conjecture is that if teachers sense agreement between the two levels, change takes place; if they sense incongruence and disagreement between the levels, they are dissatisfied and change will not take place.

The RTI survey and the case studies add to this analysis of change processes in schools. Among the first questions addressed to superintendents, curriculum supervisors, principals, and teachers, were inquiries about their roles in change and their sources of information concerning new ideas. The survey found that only twenty-nine states have supervisors who devote more than 75 percent of their time to mathematics education. Among those supervisors the greatest share of the time is spent on planning or developing curricula and coordinating inservice programs. For the questionnaires addressed to district level supervisors, only 26 percent of the respondents reported spending more than 75 percent of their time on mathematics. About half of these district supervisors report attending a professional meeting in mathematics on a yearly basis, but only 16 percent of the K-6 supervisors and 31 percent of the 7-12 supervisors belong to the National Council of Teachers of Mathematics. (1:33-48)

At the school level, principals play an important role in approving, if not stimulating, curricular and instructional change. In general, it appears that principals are very seldom from mathematics or science backgrounds. Only 6 percent of the responding secondary principals indicated an undergraduate major in mathematics, while 47 percent were in social studies or language arts areas. These principals expressed concern about their ability to adequately supervise mathematics instruction, but appear to place confidence in their mathematics resource teachers, chairmen, or teaching staff. (1:46-48)

When asked to assess the recent federal government role in teacher education and curriculum change, many teachers reported attending at least one NSF institute, conference, or inservice program. Table 1-7 indicates that the frequency is greatest among secondary teachers and current state supervisors, not a surprising result in view of the focus of NSF efforts for many years.

Table 1-7. Percent of Supervisors, Principals, and Mathematics Teachers Attending One or More NSF Institutes or Conferences*

State Supervisors	77
K-6 District Supervisors	18
7-12 District Supervisors	39
K-6 Principals	10
7-9 Principals	13
10-12 Principals	25
K-6 Teachers	5
7-9 Teachers	25
10-12 Teachers	37

*Source: (1:69)

During the case study interviews nearly all mathematics teachers commented favorably on these institute experiences. They frequently mentioned that the focus and level of activity in the institutes were not really very helpful in their daily teaching, but nonetheless felt the institutes should be continued.

The NSF institutes that I attended were well worth all the money. I'm sure that if I had not attended these institutes I would not have been able to do as good a job as I have done... A college graduate with a degree in mathematics is not really prepared to teach high school. They don't teach you how to deal with kids and you also don't get much of a chance to get your head together with respect to math instruction. All math teachers should be encouraged to take an NSF institute at least every three to five years. (3-7:30)

We mentioned earlier that very few schools are currently using any of the federally developed curriculum programs in mathematics. School system superintendents were asked to assess the impact and future need for federal support in curriculum development. While 58 percent agreed that past federal support has improved the quality of alternatives available to schools, only 27 percent agreed that those programs have greatly improved the quality of classroom instruction. The superintendents strongly urged that greater efforts be mounted for dissemination and training for implementation of new programs. While a variety of evidence suggests that federal involvement has enriched curriculum alternatives, the superintendents were about evenly divided on the question of whether federal support tends to create a nationally uniform curriculum. (1:77)

Given the apparently limited exposure of administrators and teachers to innovations promoted through NSF institutes and conferences, it is natural to ask what sources of information are used and valued by each group. As Table 1-8 indicates, teachers are a valued source of information for nearly everyone concerned with mathematics curriculum and instruction. Professional meetings and journals also reach many different audiences. State supervisors do not appear to be particularly effective conduits for information since they, like principals and teachers, appear to get and share most of their ideas with colleagues in similar positions. There are barriers to change in this communication network. The case study interviews illuminated several of these.

First and foremost is the simple fact that teachers currently work very hard coping with the day-to-day demands of 100 to 200 students in 5 to 6 classes. As case study observer Wayne Welch noted, because of the increasing difficulty and decreasing satisfaction of teaching,

Teachers tend to resist those things that make their job more difficult and are attracted to those things

Table 1-8. Percent of Supervisors, Principals, and Teachers Indicating Each Source of Information as Very Useful*

Source	Supervisors State	Supervisors 7-12	Principals 7-12	Teachers 7-9	Teachers 10-12
Teachers	23	29	36	56	39
Principals	6	15	43	22	11
Local Supervisors	56	12	38	18	16
State Supervisors	55	13	13	3	4
College Courses	6	15	26	28	30
Local Inservice	22	22	28	25	23
Federal Workshops	26	11	16	16	19
Professional Meetings	79	31	50	22	25
Journals	91	49	62	40	42
Publisher Representatives	33	14	8	9	11

*Source: (1:151-152)

> *that make it easier or more effective. Resistance to innovation, appeal of teaching bright students, need for discipline, desire for smaller classes, resistance to administrative requests for personal goals are all explained by considering teaching in this light. (3-5:13)*

Another observer, Rob Walker, took a more sympathetic view.

> *It is fashionable in some circles to accuse the teachers of failing to implement the curriculum innovations that have been made in science over the last twenty years. It is often implied that the teachers do not want to change the way they teach and will do all they can to avoid doing so. Without wishing to imply that the teachers portrayed here should change their teaching, I think it is quite obvious that most innovative programs are beyond their reach simply in terms of equipment, space, and resources. (3-6:23)*

A second, more subtle, factor inhibiting change is the reported prevalance at all levels of schooling of a "future orientation." Teachers feel a heavy responsibility to get students prepared for the next mathematics course. The goal was stated colorfully by a junior high school teacher.

> *This is it boy; if they don't get it now, they never will! This is the last chance. ... They just have to be prepared for high school or that's all she wrote.... My job is to help these little buzzards to realize that (the importance of preparation) before it's too late. (3-1:12)*

When, in the survey validation of these case study impressions, teachers were asked about the importance of preparation for the next course, 82 percent of the junior high school teachers saw this as a heavy expectation placed on them. (3-14:31) In one sense the "preparation for the future" is simply a vague exhortation for students to study mathematics in anticipation of some unspecified payoff in later years. But another effect is to lock into place a curriculum that is really built on strong traditional expectations held by teachers at one level for the students they receive from other teachers. Though the United States has no national curriculum, there is a *de facto* curriculum established by tradition and there appears to be no educational policy body with power to make major change.

This set of traditional expectations extends beyond the content of school mathematics to the pedagogy. Several case study observers noted in mathematics teaching something akin to the cultural rituals identified by sociologists and anthropologists. As one teacher put it

> *I still think America came farther and faster than any nation in history under the old method of teaching, where we had some discipline in the classroom, we did some drill because it was what teachers deemed was necessary, we didn't have to try to justify all that we did. (3-12:33)*

When parents responded to the issue of hand calculators, for example, the emotion in their response suggested that the real issue was a sacred ritual of education, not practical utility. Teachers and parents also commented on the nonmathematical goals implicit in teaching. They believe students should be encouraged to work hard, keep busy, be polite, compete, aspire to improve, work independently, and prepare for things to come.

> *Kids are lazy, people are lazy, I'm lazy—and you're going to get by with as little as you can...I think they should be required to take a little more. The program is getting watered down. (3-12:35)*

These traditional and emotion-laden expectations of mathematics education certainly act as a powerful influence on attempts to change.

Given all these factors influencing the rate and character of possible change in mathematics education, there remains a simple and fundamental reason why major change is not likely in the near future. Despite highly publicized criticism of school mathematics, a large majority of people believe current high school programs are satisfactory. The survey follow-up to the case studies found over 90 percent of all administrators, supervisors, teachers, students, and parents judged the overall quality of the high school mathematics program either satisfactory, very good, or excellent. (3-18:93) While there are undoubtedly many mathematics teachers who do not share this enthusiasm for current programs, they face a tremendous challenge in stimulating and carrying out any major change.

The Task Ahead

For many teachers, supervisors, and curriculum developers, the picture of school mathematics assembled by the three status surveys will contain few surprises. Many of the observed curricular and instructional patterns match trends being discussed informally at meetings and in the pages of professional journals. But the national character of mathematics education is certainly more complex than any sum of common practices. The most discouraging feature of the three NSF studies is the consistent pattern of great differences between apparent reality of mathematics education in most schools and the recommendations or practices of many prominent teachers, supervisors, and professional organizations. For instance, it appears that a large majority of elementary teachers believe that their sole responsibility in mathematics teaching is to develop student facility in arithmetic computation—this at a time when availability of calculators has made such goals widely questioned. Secondary mathematics teachers find it difficult to motivate their students or to induce lasting learning, yet they seem basically satisfied and they resist efforts that propose changes in the content or instructional style of their courses.

Mathematics teaching is a very demanding profession and the social context of contemporary education does little to ease the task. The reported teacher reactions to current pressures are neither surprising nor unreasonable. They constitute facts of life that must be dealt with by anyone who seeks change. Nonetheless, the signs of dissatisfaction should challenge everyone teaching mathematics today to re-examine the content and process of current programs.

> To what extent does the "average" mathematics program described above reflect your own situation?
>
> How do you cope with the problems that seem widespread?
>
> What changes in school mathematics do you believe would be most useful and how can they be brought about?
>
> What role should the NCTM play in future developments to improve school mathematics?

The NSF studies provide a backdrop of information and questions that can help stimulate and guide critical analysis and reporting of successful practices. We urge you to dig more deeply into the reports themselves and to share your insights with others in the Council.

References

[1] Weiss, Iris. *Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education*. Research Triangle Park, North Carolina: Research Triangle Institute, 1978.

[2] Suydam, Marilyn N., and Osborne, Alan. *The Status of Pre-College Science Mathematics, and Social Science Education: 1955-1975*. Vol. II: Mathematics Education. Columbus: The Ohio State University Center for Science and Mathematics Education, 1977.

[3] Stake, Robert E., and Easley, Jack, eds. *Case Studies in Science Education.* Urbana, Illinois: University of Illinois, 1978.

Volume I: The Case Reports.

Chapter 1: River Acres by Terry Denny
Chapter 2: Fall River by Mary Lee Smith
Chapter 3: Alte by Louis Smith
Chapter 4: BRT by Alan Peshkin
Chapter 5: Urbanville by Wayne Welch
Chapter 6: Pine City by Rob Walker
Chapter 7: Western City by Rodolfo Serrano
Chapter 8: Columbus by James Sanders and Daniel Stufflebeam
Chapter 9: Archipolis by Jacquetta Hill-Burnett
Chapter 10: Vortex by Gordon Hoke
Chapter 11: Greater Boston by Rob Walker

Volume II: Design, Overview, and General Findings.

Chapter 12: The Various Aims of Science Education by Margaret Steffensen
Chapter 13: The K-12 Curriculum
Chapter 14: Pluralism and Uniformity
Chapter 15: Student Learning
Chapter 16: The Teacher in the Classroom
Chapter 17: The School and the Community
Chapter 18: Survey Findings and Corroborations by Elizabeth Knight Dawson

[4] Osterndorf, Logan. *Summary of Offerings and Enrollments in Public Secondary Schools, 1972-73*. Washington, D.C.: National Center for Education Statistics, 1975.

[5] Quick, Suzanne. "Secondary Impacts of the Curriculum Reform Movement: A Longitudinal Study of the Incorporation of Innovations of the Curriculum Reform Movement into Commercially Developed Curriculum Programs." Unpublished Doctoral Dissertation, Stanford University, 1977.

[6] Hoetker, J., and Ahlbrand, W. "The Persistence of the Recitation." *American Educational Research Journal,* Vol. No. 0, pp. 1969.

Mathematics Teaching Today: Perspectives from Three National Surveys for the Elementary Grades

James T. Fey[1]

Introduction

When educators are asked to identify the crucial problems in school mathematics today, they frequently point an accusing finger at the teachers and curricula in elementary and middle school grades. Secondary teachers are quick to criticize the computational abilities of the students they receive from elementary school and to characterize the problem with sentiments like those in the following quotations.

*They don't know when you have 4 divided by 2 which number is on the outside and which is on the inside. But they really know their set theory. I think it is terrible. (3-I:98)**

I don't have to try to communicate with elementary colleagues... I know they don't know mathematics. (3-I:102)

I wish they were almost taught no theory down there. Back to basics. That means delaying the teaching of theory. (3-I:102)

It is not uncommon to hear elementary teachers responding to such complaints with remarks like,

Modern mathematics? I dislike it. The (text) shows three ways when one will do. The brass tacks are learning addition and subtraction. That's it. (3-I:131)

You might as well forget about teaching conceptual mathematics to 75 percent of the children in elementary school...(They) are not only bored—they hate it. (3-I:134)

We are fortunate not to have gone way out for the new math. We have stuck to the basics throughout it all and the results that are coming in show we were right. (3-I:33)

But this response is not at all satisfactory for teaching educators and curriculum developers who urge deemphasis of both arithmetic computation and the traditional show and drill instruction.

Small, portable, and inexpensive (calculators) have the potential for replacing the pencil and paper calculations that have been the major (and often the sole) component of elementary school arithmetic. (2:111-112)

"Research indicates that the use of manipulative materials appears to be important at all levels at least through grade 8 but they are actually used by few. (2:59)

If these comments reflect practices and controversies in elementary mathematics programs with which you work, your concerns are shared by many other mathematics teachers (K-12) across the United States. Each quotation was taken from a fascinating series of studies completed recently under the auspices of the National Science Foundation (NSF).

Much of the recent controversy in school mathematics has been sparked by disagreement over the value and effectiveness of curricular and instructional innovations sponsored by NSF, the U.S. Office of Education, and the National Institute of Education. To assess the impact of those efforts and to identify activities likely to yield valuable improvements during the next ten years, NSF commissioned three extensive surveys of recent and current practices and needs in science, mathematics, and social science education. The first study in each area was a comprehensive critical review of research and expository literature on curriculum, instruction, evaluation, and teacher education from 1955 to 1975. The review in mathematics education was done by Marilyn Suydam and Alan Osborne of Ohio State University. The second study was a collection of questionnaire surveys directed at teachers, administrators, parents, and students in grades K-12. The surveys were directed by Iris Weiss of the Research Triangle Institute (RTI). The third study was a collection of education case studies in eleven school systems by investigators under the direction of Robert Stake and Jack Easley at the University of Illinois. These case studies also employed a small scale questionnaire survey used to confirm generalizations from the case study sites.

---

[1] On behalf of an *ad hoc* NCTM committee the members of which were James Fey, Jeremy Kilpatrick, Catherine Tobin, and Harry Tunis.

*The reference scheme is explained at the end of the paper. The basic pattern is (Source-Chapter: Page).

The profile and interpretation of mathematics teaching that emerges from those studies is neither simple nor consistent. But the information and hypotheses generated by the investigations provide a context and provocation for examination of mathematics programs on a national, state, or local level. The synthesis of the studies that follows was prepared by an ad hoc NCTM committee including: James T. Fey, University of Maryland; Jeremy Kilpatrick, University of Georgia; Catherine Tobin, Lexington, Massachusetts Schools; and Harry B. Tunis, NCTM Staff with support of a grant from the National Science Foundation.

Content Emphasis in Elementary Mathematics Programs

In most schools mathematics for the first six or seven grades is a common course for all students, best described as general mathematics. Published syllabi, textbooks, and tests for these grades usually include arithmetic of whole numbers, common fractions and decimals, measurement, geometry, descriptive statistics, and applications of those topics. The inclusion of geometry, statistics, and measurement (particularly with the metric system) is a product of recent reform movements. However, the extent to which those topics have been accepted in the programs and priorities of elementary classes has been hotly debated. Thorough review of the literature of mathematics education from 1955 to 1975 led Suydam and Osborne to conclude, "As reflected in print, the content of school mathematics curricula changed.... But inclusion of 'new math' content in the elementary school may be illusory." (2:48)

Unfortunately, the RTI survey provides little additional information on the content emphases of K-6 mathematics programs. Responses from 574 elementary teachers, asked to report on their teaching of mathematics, indicate the frequency of use for various text series. Table 1-9 shows that, as of 1977, the most popular appear to be the programs of Holt, Addison-Wesley, Scott-Foresman, and Houghton-Mifflin.

Table 1-9. Percent of Classes Using Various Mathematics Textbook Series*

Textbook/Program	Percent of K-3 Classes
Holt School Mathematics (Nichols: Holt)	18
Mathematics Around Us (Bolster: Scott-Foresman)	13
Modern School Mathematics (Duncan: Houghton-Mifflin)	8
Elementary School Mathematics (Eicholz: Addison-Wesley)	8
The Understanding Mathematics Program (Gundlach: Laidlaw)	8
Investigating School Mathematics (Eicholz: Addison-Wesley)	5
Others (less than 5% each)	40

Textbook/Program	Percent of 4-6 Classes
Holt School Mathematics (Nichols: Holt)	19
Modern School Mathematics: (Duncan: Houghton-Mifflin)	10
Mathematics Around Us (Bolster: Scott-Foresman)	9
Investigating School Mathematics (Eicholz: Addison-Wesley)	9
Elementary School Mathematics (Eicholz: Addison-Wesley)	8
Others (less than 6% each)	45

*Source: (1:B-42)

Most of the textbooks in use have recent copyright dates, and in many classrooms more than one textbook is used regularly (23 percent of K-3 and 45 percent of 4-6 grade classes). But the survey did not ask teachers whether they treat the various topics in those texts with emphasis proportional to text coverage.

A set of questions was directed at the extent of metric emphasis. Table 1-10 suggests that the elementary grades are giving attention to metric concepts, but primarily as a special unit.

Table 1-10. Treatment of Metric Concepts in Elementary Mathematics Classes*

	Grades K-3	Grades 4-6
Not used	26%	13%
Special Metric Unit Only	42	43
Special Unit and Throughout Course	8	22
Introduced as needed	22	19

*Source: (1:119)

A sharper, if possibly less reliable, picture of the content dominating elementary mathematics programs comes from the eleven case studies, constructed by experienced observers who watched and talked to teachers and students over extended time periods. In summarizing the observations of science, mathematics, and social studies programs, the investigators commented, "The emphasis on a 'basic skills' curriculum was an almost universal finding in these case studies." (3-13:3) They concluded that elementary school mathematics was primarily devoted to helping children learn to compute.

If the back-to-basics movement is real, it appears that no one could be happier than the teachers themselves. Secondary teachers voice sharp criticism of the elementary school products.

I can see the results of the new math on all the students I've had here. As sophomores they don't know how to figure up percentages. It really shocks me. (3-4:9)

And elementary teachers appear to be listening. Case study observer Wayne Welch noted:

Parents, boards, and teachers see (arithmetic) as an important skill, and drill on long division appears with greater frequency in the classroom. The 'new' math is now old and,—with cries of 'Johnny can't add!'—is rapidly disappearing from the curriculum. (3-5:10)

To some this retreat from innovation will be a welcome trend; for others the direction and strength of change will be viewed with deep dismay.

Patterns of Instructional Organization and Style

Over the past twenty years the course content proposals of curriculum projects and advisory groups have received prominent support and professional scrutiny. But nearly every such syllabus innovation was accompanied by recommendations for change in teaching style. Mathematics teachers have been urged to implement discovery learning, mathematics laboratory activities with 'hands on' learning, individualized instruction, multimedia instruction, and many other promising pedagogical strategies. However, as is the case with attempted changes in the content of school mathematics, information from the NSF studies raises doubts about the extent to which any of these proposals for innovative pedagogy have influenced predominant instructional patterns.

Several parts of the RTI survey questionnaire asked teachers to describe mathematics instruction in their classes—amount of time available, allocation of that time to various activities (lecture, discussion, small groups, and so on), use of media, class size, and testing.

Elementary teachers were asked to report the average time spent on mathematics and the length of their most recent mathematics lesson. Table 1-11 indicates that mathematics fares well in comparison with science and social studies.

Table 1-11. Average Number of Minutes Per Day Devoted to Mathematics, Science, Social Studies, and Reading in Elementary School*

	Grade Range	
	K-3	4-6
Mathematics	41	51
Science	17	28
Social Studies	21	34
Reading	95	66

*Source: (1:51)

This and other related data support the common impression that reading and arithmetic are high priorities in elementary school. However, other similar studies that have relied on trained observers rather than teacher self-reports, suggest that the actual time spent on mathematics may be less than what is given here (2:53).

Class size is another variable that teachers commonly judge to be an important influence on their effectiveness. Mathematics class size is comparable to science and social studies and increases with grade level. Table 1-12 shows the average class sizes reported by teachers in the three subject areas. In grades 7-9, average class size in mathematics is lower than the other two subjects, though many would argue that it is not enough lower to make an educationally significant effect.

Table 1-12. Average Class Size in Mathematics, Science, and Social Studies at Three Grade Range Levels*

	Grade Range		
	K-3	4-6	7-9
Mathematics	24.2	27.7	26.7
Science	23.5	26.6	30.6
Social Studies	24.1	28.2	29.8

*Source: (1:67)

The common forms of organization for student groups in mathematics instruction are indicated by Table 1-13. Within these groupings the frequency of various specific instructional strategies is given by Table 1-14. The data given there are averages over grades K-6, but the breakdowns by grade range are surprisingly similar. The most noticeable trends from grades K-9 are steady increase in the frequency of tests and quizzes and steady decrease in the use of manipulatives and student involvement techniques.

Table 1-13. Percent of Class Time in Various Organizational Formats, Mathematics K-9*

	Grade Range		
	K-3	4-6	7-9
Entire Class as a Group	36	38	45
Small Groups	29	25	17
Students Working Individually	36	38	38

*Source: (1:111)

The variety of supplementary materials—print, audiovisual, and manipulative—that have become available for use in teaching elementary mathematics is truly astonishing. Table 1-15 shows that manipulatives seem to be fairly frequently used in elementary grades. Among the specific types of materials likely to be in a mathematics laboratory set-up, it appears that audio-visual materials (film strips, tapes, slides, etc.) are rarely used, but Table 1-16 shows that games and puzzles, measurement tools, activity cards or kits, and numeration and place value manipulatives are frequently used.

When teachers were asked to identify materials or facilities that needed improvement to enhance their effectiveness, they most frequently mentioned non-consumable equipment, money to buy supplies on a day-to-day basis, spaces for small groups to work, and laboratory assistant or paraprofessional help. They did not, however, indicate any strong need for hand-held calculators and apparently do not use calculators much at all in elementary mathematics instruction.

With some exceptions, such as the abstinence from calculator usage, the RTI survey data suggest elementary instruction that is varied and rich in concrete experiences with mathematical ideas. However, the reported frequencies of lecture, discussion, tests or quizzes, and individual assignments are also very high, particularly in grades 4-6. This suggests very common use of an instructional style in which teacher explanation and questioning is followed by student seatwork on paper and pencil assignments. This pattern has been observed in many other recent studies of classroom activity (2:76), including several in which actual classroom observations were the source of data.

The NSF case studies confirm this more pedestrian picture of day-to-day activity in mathematics classes at all grade levels. The following description of junior high school mathematics classes from the case study by Wayne Welch was corroborated by nearly every other observer.

Again, as in the high school, the math program is characterized by its conventional textbooks and its

Table 1-14. Frequency of Instructional Techniques in Grade K-6 Mathematics Classes*

	Percent of Classes			
	Never	Less Than Once a Week	At Least Once a Week	Approximately Daily
Lecture	34	8	20	33
Discussion	6	5	15	73
Student reports/projects	46	40	6	5
Library work	72	17	6	1
Students at chalkboard	4	15	38	42
Individual assignments	7	9	22	60
Students using manipulatives	9	37	31	19
Televised instruction	82	9	7	1
Programmed instruction	70	13	5	6
Computer assisted instruction	92	3	1	1
Tests or quizzes	8	40	42	8
Contracts	71	15	5	7
Simulations	75	16	6	1
Field trips	73	23	1	0
Guest speakers	88	9	1	0
Teacher demonstrations	9	19	29	39

*Source: (1:B-56,57)

Table 1-15. Frequency of Use of Hands-on Manipulative or Laboratory Materials*

	Never	Less Than Once a Month	At Least Once a Month	At Least Once a Week	Daily
Grades K-3	7%	12%	11%	37%	29%
Grades 4-6	10%	30%	21%	25%	9%

*Source: (1:B-56,57)

routine of correcting papers, explaining difficulties, and assigning more problems. (3-5:8)

The elementary teachers themselves give some clues to the dominance of this consistent unimaginative classroom routine. They claimed that many text techniques designed to produce understanding are instead simply confusing.

The textbook says to show method A for regrouping in addition and then to switch to method B. Every teacher in the school knows this confuses kids. So we don't show kids method A. (3-1:33)

The principles of multiplication, addition, division, and subtraction are unrelated. For example:

$$5 \times 3 = (2 \times 3) + (3 \times 3)$$
$$15 = 6 + 9$$

Why should the kids learn this? All the teachers here would agree with me. It's really a stinker. (3-1:33)

Table 1-16. Frequency of Use of Various Types of Equipment in K-3 and 4-6 Mathematics Classes*

			Percent of Classes K-3		
	Not Needed	Needed but not Available	Use less than 10 days	Use 10-50 days	Use more than 50 days
Games and Puzzles	0	7	9	25	58
Hand-held Calculators	77	15	1	2	3
Computers	85	11	0	1	1
Metric Measurement Tools	16	24	23	31	4
Nonmetric Measurement Tools	7	14	28	37	11
Activity Cards or Kits	4	20	13	28	29
Numeration and Place Value Manipulatives	14	13	14	28	29
Geometric Tools	27	20	23	18	9
			Percent of Classes 4-6		
Games and Puzzles	5	5	25	39	19
Hand-held Calculators	44	39	6	7	1
Computers	63	26	1	2	2
Metric Measurement Tools	7	29	20	32	5
Nonmetric Measurement Tools	6	13	22	39	16
Activity Cards or Kits	8	10	25	27	25
Numeration and Place Value Manipulatives	20	16	26	22	14
Geometric Tools	13	21	26	27	9

*Source: (1:B-80,81)

They have little patience with or sympathy for inquiry.

I was told that the reason the new math was brought into being was to satisfy a child's 'natural curiosity'. And I thought that was a ridiculous statement; because who's curious as to why $5+2=7$*. (3-1:31)*

I dislike our book, not enough drill, it's modern math. (3-1:31)

I am using the rote method pretty much because they have found out that with a three level you can spend all hour trying to get them to understand (and they can't). (3-1:47)

Certainly, the mathematics teaching these observers saw embodied none of the spirit of inquiry, laboratory exploration, or individualization that has been so strongly urged by a variety of experts. But, as Welch goes on to indicate, "Although it seemed boring to me, students and teachers seemed comfortable with it. Apparently it fulfills student expectations and provides the students opportunity for closure." (3-5:6) Commenting on the same phenomenon in another setting, Louis Smith recalled remarks of Hoetker and Ahlbrand.

If the recitation is a poor pedagogical method, as most teacher educators long have believed, why have they not been able to deter teachers from using it?

Or, is it not possible that the practicing teachers are right and the professors unrealistic, and that the recitation—for some reason—is the best pedagogical method? Or the only practicable one for most teachers. (6:163)

One could comfortably accept this latter explanation of predominant teaching styles and conclude that teaching, as it is now commonly practiced in mathematics classes, is about as effective as one can reasonably expect. However, the case studies and the survey produced frequent comments that students find study of mathematics boring and teachers find motivation of students to learn mathematics one of the most difficult problems they face.

> *Fifth graders are harder to motivate than are first graders. By the time they are in the fifth grade they have had the whole bit. They get the same things they didn't understand the first time back again and for the first time honest to goodness boredom is felt about mathematics—even science. (3-1:34)*

And many teachers echoed the following puzzlement about the transitory nature of learning.

> *Except for the (top students) all third graders know one thing perfect in math one day and the next it is gone ... I mean GONE. ... Now what I want you to know is that all the kids except (the best), and some of them too, have this mysterious 'forgetting' disease. (3-1:37)*

None of these complaints are new or surprising. But they do stand in contrast to the reluctance of many teachers to exploit alternative instructional styles.

Perceptions of the Abilities, Problems, and Beliefs of Teachers

One of the clearest themes running throughout the reports of case study observers was the absolutely crucial role of classroom teachers in determining the character and effectiveness of science and mathematics education. As case study author Rob Walker noted, "Any observer cannot fail to be impressed by the fact that the resources tied up in teaching here are almost entirely human resources." (3-6:23) Louis Smith noted that as he sought generalizations about education, "administrators, board members, teachers, pupils always ended up talking about individual teachers." (3-3:112)

The limits of teachers' knowledge about mathematics or about ways that young people learn place predictable limits on what the teacher can offer and accomplish in the classroom. The teachers' beliefs about the nature of mathematics and the important goals of schooling are more subtle but equally important influences in their impact on students. The survey and the case studies provide further insight into the status of mathematics education by analysis of teacher abilities, attitudes, and beliefs.

Elementary teachers currently average more than 12 years of teaching experience. About one-third hold a graduate degree and 45 percent were taking a course (not necessarily mathematics) for college credit in 1976-77. In grades K-3 only 4 percent of the teachers are men, and in grades 4-6 only 25 percent are men. The mathematical competence of these elementary teachers is, in all likelihood, much greater than that of the average teacher twenty years ago. Suydam and Osborne report that in 1957 only 12 states required a mathematics course for certification (7 content and 5 methods). However, they felt justified in concluding that by 1975 there had been a significant increase in the mathematical requirements for prospective elementary teachers. (2:130,150,164)

The RTI survey did not indicate the extent to which elementary mathematics is taught by subject matter specialists, but of the teachers asked to report on their mathematics responsibilities, 49 percent felt very well qualified to teach mathematics and another 46 percent felt adequately qualified. Furthermore, principals and district supervisors share this confidence in the ability and interest of K-6 mathematics teachers.

Table 1-17. Elementary Teachers Perceptions of Their Qualifications in Each Subject*

	Not Well Qualified	Adequately Qualified	Very Well Qualified
Mathematics	4%	46%	49%
Science	16	60	22
Social Studies ...	6	54	39
Reading	3	32	63

*Source: (1:142)

This strong expression of confidence in elementary teachers of mathematics should be encouraging. However, state supervisors of mathematics saw lack of teacher interest in mathematics and inadequate preparation to teach mathematics as the most serious problems in grades K-6. This contrast suggests that K-6 teachers and their immediate supervisors believe in the computation curriculum and in "tell and drill" methods of instruction—pattern of beliefs that will not please many mathematics educators, but constitutes a formidable barrier to change. When teachers in grades K-6 were asked to specify areas in which they would like assistance, they mentioned most often: (1) learning new teaching methods, (2) obtaining information about instructional materials, and (3) implementing discovery/inquiry and hands-on approaches in teaching. (1:B-105,108) When these same teachers were asked to identify the most serious problems they face in teaching mathematics, they most frequently mentioned: (1) insufficient funds for purchasing equipment and supplies, (2) lack of materials for individualizing instruction, (3) inadequate student reading abilities, (4) lack of planning time, and (5) class sizes too large. (1:B-125)

When one looks for help in ameliorating these conditions, the obvious first line of responsibility is supervisors and administrators. The RTI survey results give reason for concern about prospects for help from these sources. The survey found that only twenty-nine states have supervisors who devote more than 75 percent of their time to mathematics education. Among district level supervisors, only 26 percent reported spending more than 75 percent of their time on mathematics. About half of these district supervisors report attending a professional meeting in mathematics on a yearly basis, but only 16 percent of the K-6 supervisors belong to the National Council of Teachers of Mathematics. (1:33-45)

At the school level, principals plan an important role in approving, if not leading, curricular and instructional change. Not surprisingly, very few elementary principals have undergraduate majors in mathematics (4 percent in K-3, 7 percent in 4-6). However, few feel "not well qualified" to supervise mathematics (12 percent K-3, 8 percent 4-6). (1:47) Very few elementary supervisors, principals, or teachers have attended any NSF Institutes or conferences (18, 10, and 5 percent respectively). (1:69) Furthermore, only 8 percent of K-6 schools are using any of the innovative curricula whose development was sponsored by NSF. (1:79)

These survey data give a sketchy quantitative outline of the teacher qualifications, needs, and potential sources of help in elementary mathematics. When combined with earlier information about current curricula and teaching styles, the data leave an overall impression well described by Stake, who viewed the situation through the eyes and ears of the eleven case study observers:

(The teachers) saw themselves in a serious, not very exciting business; the business of education. They saw themselves as pretty good businessmen, wishing that times would change for the better, but confident that they could deliver on their promises and pretty well satisfied that there is not really a better way to run the show. (3-5:25)

Not everyone connected with mathematics education will read that description of elementary mathematics teaching and teachers with such satisfaction. But anyone seeking to change the status quo must probe deeper to understand the teacher beliefs and educational traditions or boundary conditions tht produce our system. The case study interviews were designed for just this exploratory investigation and produced numerous quotations that are clues to the puzzles.

We have already mentioned the predominance of teacher belief that elementary mathematics is properly all about computation and that repetitive verbal learning is the basic means of acquiring mathematical knowledge, the frustration of students' limited reading skills, their modest motivation to learn, and their propensity for rapid forgetting. The case study perspectives identified several other useful ways of understanding the nature and dynamics of change in K-6 mathematics.

Ritual and Socialization in Mathematics—Much of the excitement surrounding emergence of low cost hand-held calculators has been generated by the prospect that elementary schools will need to devote far less time to developing facility with computational algorithms. It appears that current elementary teachers feel no pressure for such impending change in curricular emphasis. However, the case study observers did not see this situation as a reflection of rational analysis; instead, they sensed that acquisition of computational skill through unquestioning hard work is valued as a moral and socializing experience central to education.

I still think America came farther and faster than any nation in history under the old method of teaching, where we had some discipline in the classroom, we did some drill because it was what teachers deemed was necessary, we didn't have to try to justify all that we did. (12:33)

Parents said,

I think using hand calculators is an awful shame because that's why our brains are going so lazy. (12:34)

Kids are lazy, people are lazy, I'm lazy—and you're going to get by with as little as you can...I think they should be required to take a little more. (12:35)

It seemed clear from these comments, and many like them, that teachers and the public see traditional subjects and instructional methods, particularly arithmetic, as vital in fulfilling the schools' obligation of training students to work hard, keep busy, be polite, compete, aspire to improve, and prepare for things to come.

Future Orientation—Teachers of mathematics commonly complain that motivation of students is their hardest task. It seems that students are always learning skills and concepts for which immediate application is impossible to demonstrate. As a result they are usually reassured with the admonition that they will need the learning to succeed in later courses. Elementary teachers are acutely aware of this preparation responsibility and their goals are heavily influenced by what they perceive to be the expectations of teachers in later grades.

This is it boy; if they don't get it now, they never will! ...My job is to help these little buzzards to realize that (the importance of preparation) before it is too late. (3-1:12)

And when teachers of later grades are asked about their expectations, they agree, by a heavy majority, with the contention that the basics must come first.

The study of mathematics takes levels of maturity. You have to take step one before you can take step two. There is a definite hierarchy of material. You can't hope to be creative until you've mastered the basic program of studies. (3-2:11)

Most teachers assume that it is their responsibility to get children ready for the lessons of subsequent years. Is this not true? Seventy-nine percent of our elementary math supervisors said, 'It is true.' Eighty-two percent of our junior high math teachers said, 'It is true'. (3-14:31)

Though the United States has no national curriculum or body with authority to change dominant practice, there does appear to be an informal network of traditional intergrade expectations acting as a powerful force in determining curricula.

The Task Ahead

For many teachers, supervisors, and curriculum developers, the picture of school mathematics assembled by the three status surveys will contain few surprises. Many of the observed curricular and instructional patterns match trends being discussed informally at meetings and in the pages of professional journals. But the national character of mathematics education is certainly more complex than any sum of common practices. The most discouraging feature of the three NSF studies is the consistent pattern of great differences between apparent reality of mathematics education in most schools and the recommendations or practices of many prominent teachers, supervisors, and professional organizations. For instance, the studies suggest that a large majority of elementary teachers believe that their sole responsibility in mathematics teaching is to develop student facility in arithmetic computation—this at a time when availability of calculators has made such goals widely questioned. Secondary mathematics teachers find it difficult to motivate their students or to induce lasting learning, yet they seem basically satisfied and they resist efforts that propose changes in the content or instructional style of their courses.

Mathematics teaching is a very demanding profession and the social context of contemporary education does little to ease the task. The reported teacher reactions to current pressures are neither surprising nor unreasonable. They constitute facts of life that must be dealt with by anyone who seeks change. Nonetheless, the signs of dissatisfaction should challenge everyone teaching mathematics today to re-examine the content and process of current programs.

To what extent does the "average" mathematics program described above reflect your own situation?

How do you cope with the problems that seem widespread?

What changes in school mathematics do you believe would be most useful and how can they be brought about?

What role should the NCTM play in future developments to improve school mathematics?

The NSF studies provide a backdrop of information and questions that can help stimulate and guide critical analysis and reporting of successful practices. We urge you to dig more deeply into the reports themselves and to share your insights with others in the Council.

References

[1] Weiss, Iris. *Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education*. Research Triangle Park, North Carolina: Research Triangle Institute, 1978.

[2] Suydam, Marilyn N., and Osborne, Alan. *The Status of Pre-College Science Mathematics, and Social Science Education: 1955-1975*. Vol. II: Mathematics Education. Columbus: The Ohio State University Center for Science and Mathematics Education, 1977.

[3] Stake, Robert E., and Easley, Jack, eds. *Case Studies in Science Education*. Urbana, Illinois: University of Illinois, 1978.

Volume I: The Case Reports.

Chapter 1: River Acres by Terry Denny
Chapter 2: Fall River by Mary Lee Smith
Chapter 3: Alte by Louis Smith
Chapter 4: BRT by Alan Peshkin
Chapter 5: Urbanville by Wayne Welch
Chapter 6: Pine City by Rob Walker
Chapter 7: Western City by Rodolfo Serrano
Chapter 8: Columbus by James Sanders and Daniel Stufflebeam
Chapter 9: Archipolis by Jacquetta Hill-Burnett
Chapter 10: Vortex by Gordon Hoke
Chapter 11: Greater Boston by Rob Walker

Volume II: Design, Overview, and General Findings.

Chapter 12: The Various Aims of Science Education by Margaret Steffensen
Chapter 13: The K-12 Curriculum
Chapter 14: Pluralism and Uniformity
Chapter 15: Student Learning
Chapter 16: The Teacher in the Classroom
Chapter 17: The School and the Community
Chapter 18: Survey Findings and Corroborations by Elizabeth Knight Dawson

[4] Osterndorf, Logan. *Summary of Offerings and Enrollments in Public Secondary Schools, 1972-73*. Washington, D.C.: National Center for Education Statistics, 1975.

[5] Quick, Suzanne. "Secondary Impacts of the Curriculum Reform Movement: A Longitudinal Study of the Incorporation of Innovations of the Curriculum Reform Movement into Commercially Developed Curriculum Programs." Unpublished Doctoral Dissertation, Stanford University, 1977.

[6] Hoetker, J., and Ahlbrand, W. "The Persistence of the Recitation." *American Educational Research Journal*, Vol. No. 0 pp. 1969.

The Teacher is the Key: A Report on Three NSF Studies

James V. DeRose
J. David Lockard
Lester G. Paldy

Introduction

In 1976, in response to congressional criticism of its precollege program, the National Science Foundation undertook to determine the state and needs of science, social studies, and mathematics education in this country. In order to acquire the information it sought, NSF awarded grants for three studies: (1) a survey of school administrators, supervisors, and teachers, conducted by the Center for Educational Research and Evaluation of the Research Triangle Institute, North Carolina, of which Iris Weiss was project director; (2) a literature search by Stanley L. Helgeson, Patricia E. Blosser, and Robert W. Howe of the ERIC Center for Science, Mathematics and Environmental Education at the Ohio State University; and (3) a number of in-depth case studies conducted in a variety of school systems, directed by Robert E. Stake and Jack A. Easley of the University of Illinois-Urbana. This report will deal—briefly—with the findings of the three studies (published in 1978) which are of particular interest and importance to those teaching science—whether as a separate discipline in junior or senior high school, or as part of the curriculum in a self-contained elementary school classroom—and to science educators responsible for the education of these teachers.

The studies bring into focus current practices and conditions that affect science teaching. The findings are extensive and documented. Although most science teachers will find little of which they are not already aware, the studies do serve effectively to establish those local conditions, practices, and trends which are generally characteristic of schools nationwide. As a consequence, it will be easier for teachers and administrators to isolate those problems which, being locally derived, may be solved effectively by local initiatives, from those problems which stem from larger societal, economic, and political conditions, and are therefore much more difficult to solve by independent local efforts.

How Do Teachers Teach?

What is taught and how it is taught are two questions with very interrelated answers. The major activities in science curriculum development in the 1955 to 1975 period were funded by the National Science Foundation. The NSF-sponsored curriculum improvement projects presented science content compatible with the practicing scientists' view of science which required a nontraditional teaching approach characterized by openness, flexibility, inquiry, and student involvement in more than just reading about science and watching demonstrations.

It is encouraging to report that the study found that there is more use of laboratory and hands-on instruction than was the case before the NSF curricula were developed and implemented. The NSF teacher institutes have also had an impact: 73 percent of the teachers who had attended one or more of the institutes arranged for their students to have hands-on experiences at least once a week, as contrasted with 42 percent of the teachers who had not attended institutes. There has also been an increase in the use of student-centered classroom activities as a result of the institute program.

Despite the influence of the NSF-sponsored curricula and institutes, however, classroom observers reported that at all grade levels the predominant method of teaching was recitation (discussion), with the teacher in control, supplementing the lesson with new information (lecturing). The key to the information and the basis for reading assignments was the textbook.

Most questions were observed to be concerned with definitions and the acquisition of information, and were mostly taken from the textbook. Classrooms in which individual thought, inquiry, and open discourse took place were noted but not frequently. Still

---

This report appeared originally in *The Science Teacher,* Volume 46, Number 4, April 1979.

less often did the teacher assume the role of a fellow learner.

The next most frequently observed activity was the demonstration, conducted in two our of five classes once a week or more. The number of classes using hands-on experiences once a week or more increases from one-in-three in elementary schools to three-in-four in senior high schools.

Student reports and projects are used once a month or more in half of the classes. Other teaching techniques such as field trips, guest speakers, simulations, contracts, programmed instruction, and similar programs are used once a month or more in less than 10 percent of the classes and are never used in 50 percent of the science classes surveyed—with the exception of field trips, which are never used in 31 percent of the classes. Time spent in various instructional arrangements does not differ significantly for the various grade levels. Approximately half of the time the entire class is arranged as a group, one-sixth of the time it is divided into small groups, and about one-third of the time students work individually.

In all of the schools surveyed, the national trend to make curricula more explicit and learning more measurable was evident. Schools had prepared or adopted statements of objectives and had developed criterion test items with which to determine student accomplishment of objectives. In general, teachers and administrators reacted favorably to the manageability and clarity of the objectives-based system, but no evidence had been gathered by the schools surveyed to indicate that achievement levels of students had increased as a result.

What Do Teachers Teach?

What do these reports tell us about the science curriculum? Few, if any, surprises emerge. In senior high schools, year-long biology, chemistry, and physics courses still comprise the major part of the curriculum. Most states still require only one year of high school science, and do not require any specific course.

The Dominant Textbook. The secondary school science curriculum is ordinarily organized with a textbook as its core; more than half the science teachers sampled in the survey reported that they used a single test, with approximately one-third indicating that more than one text was required for their courses. Texts are usually selected by individual teachers and teacher committees. Principals and supervisors are sometimes involved in text selection, but the survey indicates that parents, students, and school board members have little to say in this process even though the text often defines a complete curriculum. Despite the attention given in the media to a few isolated instances, texts do not often generate controversies.

Some states have text-adoption procedures which require books purchased with state funds to be selected from an approved statewide list, but schools in these states often broaden their choices by using local funds when available. The texts themselves frequently reflect the influence of the curriculum projects developed with the support of the National Science Foundation during the 1960s, and this must surely be regarded as a significant residue of those efforts. Even though the choice of text is usually theirs alone, many teachers criticize the text they are using as having too difficult a reading level for many students.

Inquiry and Laboratory Methods. Survey data suggest that the domination of the curriculum by the textbook tends to discourage use of inquiry techniques which require students to do more than look up information in the text and then recite or record it. In addition to reading and recitation, teachers report that workbook exercises provide much of whatever activity exists in typical classrooms. Even when teachers seek to use laboratory investigation and inquiry techniques, barriers such as inadequate timeblocks in the schedule, shared classrooms, and inadequate facilities and supplies tend to foster more passive, text-oriented approaches. While many teachers report that inadequate funding makes laboratory activity difficult, the surveys indicate that lack of student motivation and the demanding nature of inquiry teaching may be equally significant. Additional funds might ease some problems, but there is little evidence presented here that funds alone would be sufficient to create more vital programs, at least not in the amounts likely to be made available.

Curriculum Priorities. Even as scientific literacy programs for the majority of students essentially end after the 10th-grade biology experience, science itself is given relatively low priority within most secondary schools in comparison to English and social studies, in which specific courses are usually required subjects throughout the student's high school experience. Curriculum efforts involving teachers from several science disciplines are rare in American high schools, although larger schools often have special elective courses in fields such as oceanography, environmental science, and earth science. In many schools, these courses are designed to motivate students who would not ordinarily continue their study of science beyond 10th-grade biology, and thus represent commendable efforts to break away from more traditional patterns which have not succeeded in reaching many students.

One of the major impressions conveyed by the survey is that teachers of science courses for college-bound students have succeeded in preserving the elite characteristics of these courses for the small student populations that they serve. Many schools have tracking systems which have created alternative courses with less demanding requirements for students who are either not capable or are insufficiently motivated to deal with the material presented in traditional biology, chemistry, and physics.

Use of Community Resources. Community or other out-of-school curriculum resources are rarely used by science classes. The Case Studies, in particular, make abundantly clear that most schools (and science programs) are insular and removed from the mainstream of community activity. For example, when the schools of Columbus, Ohio, were forced to close during the winter of 1977 because of a fuel shortage, community resources were used only in a perfunctory way to continue the education of children, primarily because of inadequate planning and a lack of experience in coping with the inevitable difficulties encountered in developing a curriculum organized around unfamiliar resources.

The Learning Environment. The report suggests that science classrooms in many schools do not provide stimulating surroundings. Of course, many individual teachers have made valiant efforts to deal with problems caused by inappropriate texts, poorly prepared and motivated students, lackluster administrations, and the like. Nevertheless, the broad picture that emerges of the nation's secondary science curriculum is not encouraging, particularly when one considers the large number of students who do not continue in science beyond the 10th grade.

Even though the barriers encountered by teachers seeking to develop responsive science programs are high, there appear to be enough successes to encourage others to try. Moreover, the surveys suggest that the decentralized system of American education provides considerable latitude to teachers who wish to modify the curriculum in response to the special needs of their students and communities. When one views the constrictive character of ministerial control of education in some other countries and the inhibiting effect which this control has on their systems, one has reason to be grateful once again for the vision of our founding fathers.

Junior High Science. Even though life science has become a standard course in many schools, general science is still the only course taught in more than half of the junior high schools surveyed. However, physical and earth science programs are not uncommon. The survey suggests that the process of socialization constitutes an important educational objective in the junior high. Laboratory handouts, for example, sometimes list guidelines for appropriate classroom and laboratory behavior in addition to instructions for carrying out a laboratory activity. To some extent, the socialization objective may (but need not) inhibit inquiry and investigative approaches to learning; many may view it as unfortunate that schools have turned away from inquiry approaches in favor of text-dominated courses which stress knowledge acquisition, often by rote methods.

Elementary School Science. On the basis of the survey data, elementary school science must still be regarded as a significant problem area. Much of the difficulty stems from the fact that science in the elementary schools, not regarded as basic, is given a low priority in comparison to reading, mathematics, social studies, and health. Most elementary school teachers and, presumably, their school administrators see little relationship between science and other areas of the curriculum, a perception that existed even before the recent emphasis upon basic education.

Elementary school science, like that in junior and senior high schools, is taught primarily by lecture and recitation based on one textbook. Elementary schools invest only a very small proportion of their budgets in curriculum materials; science, perceived of as low priority, usually fares badly in the competition for scarce funds. As a result, most of the nation's elementary schools are inadequately equipped to provide a significant investigative laboratory experience to children. One of the more pessimistic findings of the surveys was that "fewer than half of the nation's elementary school children are likely to have even a single school year in which their teachers will give science a significant share of the curriculum and do a good job of teaching it."

Subjective Comments. A reader of these studies may conclude that the science curriculum is responding ponderously, at best, to changing social conditions, individual needs, developmental patterns of students, and perceptions of community and political realities. The curriculum cannot be considered in isolation from the setting in which education takes place, but it may be useful to make some brief subjective comments on the curriculum, considered in a somewhat more limited sense: on the materials, practices, and perceptions described in the studies.

It appears that many science courses include material which is inappropriate for most of the students studying at that level. For example, high school biology courses often contain substantial amounts of biochemistry and molecular biology, even though the majority of biology students have not yet studied chemistry. It is true that these portions of the text are not studied by all students, but one is left with the impression, nevertheless, that many students are asked to spend a significant amount of time memorizing complex details of biochemistry and molecular processes even though most have neither the necessary access to experimental evidence nor the reasoning skills needed to follow the intricate conceptual arguments. In a similar manner, chemistry courses are likely to be replete with rote presentations of quantum mechanical models of atoms and molecules.

One can speculate that many school science programs may be strongly influenced by unrealistic perceptions of what colleges expect high school graduates to know, with the result that students are required to study material which they cannot understand in any significant way and which is unrelated to their current interests, on the grounds that the material will be needed later. By now, it is painfully obvious that for most "later" never arrives.

In summary, some readers will conclude that one of the major inferences that can be drawn from these reports and case studies is that much of the secondary school science curriculum is mismatched to the interests and needs of the majority of students in our schools who will not pursue scientific or technological careers. In the current political setting of American education, characterized by declining enrollments, resource shortages, and unrealistic social expectations of schools, the inappropriateness of the curriculum may contribute heavily to the frustration of teachers, the malaise of students, and the dissatisfaction of parents. Those whose interpretation of these reports leads them to arrive at such a conclusion may well expect policy makers, teachers, and citizen groups to re-examine the content of the school science curriculum to ensure that it is responsive to the needs of contemporary America.

Of course, readers' impressions derived from the reports of site visitors and the results of questionnaires are inevitably influenced by their subjective views of the schools, science, and the way in which children learn. Citizens, science teachers, and policy makers at all levels need to know more about what is being taught, and whether the curriculum is, in the main, appropriate for the students to whom it is presented, taking into account their previous preparation and motivation. How well is science being taught? Do the methods convey something of the spirit of science? Is the tentative nature of science made clear? Do our science classes foster inquiry and scholarship? Quality assessment is always a sensitive matter, but these are the issues which we must engage, whether individually as teachers or collectively as faculties.

How Are Teachers Educated?

The studies contain information on the background and education of the teachers in the sample populations that suggests some reason for concern. While each state sets minimum requirements for science teachers, state certification criteria still do not reflect those proposed by professional associations which call, particularly, for more science content. This is especially crucial in the elementary and junior high schools, where most of the science instruction occurs. It is at these levels that teachers have the least adequate science content preparation and the poorest physical facilities, while at the same time the fewest certification programs available to them. Secondary school teachers fare better: Only slightly more than one-tenth of them are currently teaching one or more science courses for which they feel inadequately qualified. On the other hand, 16 percent of the elementary teachers surveyed feel "not well qualified" to teach science, and less than a quarter of them feel "well qualified" to do so. This feeling of inadequacy by elementary teachers to handle science instruction permeates all three studies and indicates a need for some serious work by all those who can help alleviate this problem.

Reactions to the adequacy of preservice education for science teachers were mixed. The Case Studies indicated some low estimates of the ~~quality~~ of education courses and a concern by observers that many science teachers leave college with so little command of the substantive content of the NSP-initiated curricula that they are in need of remediation the instant they graduate. In addition, teachers feel threatened by the pressure for accountability and the "back-to-basics" movement for which they were not prepared in preservice training.

It is discouraging to note, too, that knowledge of science is rarely considered basic by the state boards of education, and science education is rarely included in state needs statements. This in itself may be indicative of a low interest by the general public in supporting high-quality science instruction.

Improved science teacher education, both pre- and inservice, is an important need. While continuing research in science teaching/learning is vitally needed, the results of that research need to be better communicated and applied in both the preservice and inservice programs. One of the studies' observations is that there is a critical need for preservice and inservice science education to be viewed and dealt with as a continuous program rather than as discrete entities handled by two different sets of people. This presents a challenge to the teacher-training institutions not only to do appropriate follow-up studies on their graduates but to work even more closely with the school districts that employ them.

Although the studies seem to indicate that today's secondary school science teachers are better educated than were those of the 1950s, both the teachers' perceptions and the findings of research indicate that there is still a critical need for inservice education. Approximately half of the elementary science teachers and more than 41 percent of the secondary science teachers took a course for college credit in 1976-77. Sizable numbers of teachers have earned one or more degrees beyond the bachelors: more than half of the secondary school science teachers and just over a quarter of the elementary science teachers. However, since little of this graduate study by elementary teachers is done in academic science courses, there is a pressing need for both preservice and inservice training to overcome their fear of teaching science, so that they may teach it well and with enthusiasm.

A consistent theme throughout the documents was the high value ascribed to NSF-sponsored activities in the education of science teachers. The most frequently attended programs were the NSF Summer Institutes: Approximately two-thirds of the state science supervisors and almost 40 percent of the grade 7-12 science teachers surveyed had participated in one or more of these. Unfortunately, less than a fifth of the elementary science teachers had done so.

The second most often attended activity reported was the In-Service Institute, with participation by 18 percent of the grade 7-12 science teachers and 10 percent of the elementary teachers. While the evidence is overwhelming that these government-supported programs were considered to be of major help to science teachers, the majority of teachers currently teaching have not participated in them. This fact should be carefully noted and appropriate action taken. It is absolutely essential that elementary teachers be given continuous inservice and supervisory consultant help in science and in the teaching of science since their education does not include any significant study in these two areas.

Who Helps the Teacher?

Most school districts have coordinated sequences of courses in print. But teachers at each grade level who were critical of their students' previous learning deviated from the syllabus as they saw fit. The lack of articulation in science curricula between grades, within schools, and between different schools at the same level is a significant finding. Individual teachers—within broad limits—select the content and methods which they believe appropriate, but the study found that teachers were more on their own than they wanted to be. The need for leadership in coordinating and directing individual teachers' efforts and initiatives toward common goals was apparent but unfulfilled.

Federal and state offices and legislation which have increased administrative duties, plus local opposition to increasing school costs, have fostered the trend both to decrease the number of central administrative offices and to redirect their efforts from "pedagogical to management matters." Decentralization of authority has moved some of the management problems to building principals, leaving them less time to work with teachers in developing and implementing the educational program. The study found that only one in five of the districts surveyed employed full-time science supervisors/coordinators and that two in five school districts had none.

In the schools, instructional help and leadership for teachers can come from the school principal and/or supervisory personnel. The study found that about one-fourth of the principals in any grade range felt that they were "not well qualified" to supervise science instruction. The percentage of department chairmen found in the schools decreased from a high of 74 percent in senior high schools to a low of 27 percent in the primary grades. Chairmen who received additional compensation increased from a low of one in ten in the primary grades to one in two in senior high schools.

Teachers who had consultant and supervisory help were more satisfied than those who had to work more or less on their own. Elementary teachers, especially, receive little supervisory, consultant, and leadership support in teaching science, although they are most comfortable when such support is available. The studies found also that candidates for elementary teacher certification are "seldom required to take more science content than that required for the general education component of their undergraduate program." Thus teachers who are least well prepared to deal with the teaching of science are given the least assistance.

More and more, two separate systems—management and instructional—are developing within the schools and are interacting less and less. The management system absorbs the energies and time of administrators at both the central administration and individual school levels. The instructional system functions through the efforts of individual teachers working largely without leadership and direction except in those few instances where curriculum and supervisory personnel are available. The need is evident. The absence of curricular and supervisory direction is subject to local attention and correction by local schools' initiatives. The development of an effective science program requires constant attention, leadership, and support; it cannot be left to develop by chance through the unorganized and undirected efforts of individual teachers, regardless of how excellent these individual efforts may be.

With What Do Teachers Teach?

The individual classroom teacher still determines the primary mode of instruction in most classrooms, with the textbook the primary tool. Less than 10 percent of the schools have used practices such as modular scheduling or television instruction. Nor do the majority of teachers at any grade level consider computers or computer terminals necessary. Similarly, most science classes do not use cameras. While fewer than 15 percent of science classes make use of greenhouses, almost 40 percent would use them if they were available. Almost identical figures were given for use of weather stations. Microscopes and scientific models, on the other hand, are widely used. Almost 30 percent of K-3 science classes use microscopes, while an additional 20 percent would like to have them. Usage goes up to more than 60 percent in fourth grade and remains at least that high through all of secondary school. Even though a third of grade 10-12 classes use calculators, only a tenth of junior high school classes use them, and only about 2 percent of elementary schools report any calculator usage.

Financial Needs. Although little information was collected about the financial support of science instruction, that which was gathered is worth sharing. The greatest single concern of almost everyone involved in education is for an improved program of financial support. While the percentage of financial support for the schools from federal and state sources has increased since 1955, federal support for science education has declined since the late 1960s. Since state support tends to follow federal trends, state support for science education has also declined and is likely to continue to do so.

At the time of the study (1977), the average per pupil expenditure in school districts across the nation was $1,246. A recurring concern in the Case Studies was that increasing energy costs and frequent voter rejection of special school levies were reducing funds available for the school science program. Relatively few schools have specific budgets for science equipment and supplies. In general, schools are more likely to have specific budgets for science supplies than for equipment, and secondary schools are significantly more likely than elementary schools to have specific budgets for both.

A sizable number of school districts—over one-third—did report receiving funds in 1975-76 from the National Defense Education Act for facilities, equipment, and supplies used in science instruction, and one-fourth got similar funding from the Elementary and Secondary Education Act in the same school year. On the other hand, only a very small number of school districts received science instruction funding from other government grants, specific state grants, private foundations, or parent organizations.

Teachers considered inadequate facilities, insufficient funds for purchasing equipment and supplies, and lack of materials for individualized instruction as the three most serious problems affecting science instruction. More than half of them wanted money to buy supplies on a day-to-day basis. This is an appropriate request that could be accommodated within the limits of existing financial support if administrators and teachers would work cooperatively toward a solution.

Inadequate student reading abilities and lack of teacher planning time were also considered serious problems by teachers; in addition many of them felt that the major area that needed improvement was the availability of laboratory assistants or paraprofessional help. Insufficient time to teach science was considered a more serious problem in the lower than in the upper grades.

Whom Do Teachers Teach?

Accurate enrollment figures are typically difficult to get, but the studies do furnish us with some general information and with what may be a discouraging note. While enrollments in public elementary schools were increasing from 1955 to 1969, class sizes during that period were reduced. During that same period, secondary school enrollments also increased, as did the **percentage** of students enrolled in science courses. That percentage has remained relatively stable. Enrollments, however, are now beginning to decline, with elementary enrollment declining more rapidly than secondary. Public school enrollments, particularly, have dropped considerably in some areas where integration and consolidation of schools have led to the emigration of substantial numbers of students to private and church-related schools. Inevitably, just as the increasing enrollments had an impact on schools, the decreasing enrollments will have an impact, especially financially.

Despite the fact that the percentage of secondary school students taking science courses has not decreased, it is nevertheless true that the percentage taking chemistry and physics is very small. It seems likely that one reason these numbers are so small is that only 21 percent of the states require more than one year of science in grades 9-12. For the great majority, that one year is tenth-grade biology, with fewer than half advancing into chemistry. The attrition becomes even more severe in physics, with fewer than half of the nation's chemistry students going on into that fundamental discipline.

Do Teachers Count?

Almost all elementary school science is taught by teachers in self-contained classrooms. Secondary science classes are taught more often by special science teachers. The studies found, not surprisingly, that within any classroom the science taught and the way it is taught is dependent primarily on what the individual teacher believes, knows, and does. Numerous studies indicate that the type of instruction does affect student learning and that the teacher is the most important instructional variable. The critical role of the teacher in instituting changes in science teaching is well documented.

Changes in science teaching nationwide are simply the summations of changes in individual schools functioning independently with or without strong and inspired local initiatives and leadership. Any movement to change science teaching and learning will require the wholehearted support, cooperation, and creative involvement of teachers as partners. This speaks for more effective organizational patterns in the schools in which the talents and ideas of teachers are harnessed and directed by knowledgeable school leaders. It also means a willingness on the part of teachers and administrators to be flexible and empirical in considering new content, methods, and goals.

The continuing rejuvenation of science content and teaching methods in response to new findings and societal goals requires access to and utilization of the national wisdom. Otherwise, local initiatives will amount to little more than stirring the pot! Large-scale infusions of curriculum innovations, such as the NSF-sponsored projects, are valuable in that they provide materials which no school district could develop on its own. The continued availability of such materials is essential to the growth and improvement of the science education enterprise in the United States. Indeed, most superintendents felt that federal support for continued curriculum development was essential (66 percent) and that NSF should help teachers learn how to use the new curricula (77 percent). Implementation of new materials can only take place at the local level and then only if teachers are prepared and willing to use them.

Since so much depends on teachers, it becomes necessary to focus attention there. Unfortunately, the study found that many teachers feel they have little power to change things, see little more they can do themselves, and are resigned to the status quo. Many problems and conditions which teachers feel inhibit science teaching were reported. The fact is that many of these obstacles—such as insufficient background in science, lack of equipment, inadequate room facilities, and insufficient time—can be eliminated or at least attenuated if teachers will refuse to accept them as barriers.

Teachers must assume more responsibility for creating conditions which will enhance their efforts in the classroom. This may seem an unreasonable expectation to teachers enmeshed in the demands of each day's teaching, but teachers and administrators within individual schools must find ways to provide time for unhurried thought and deliberate planning. Total and final responsibility for what happens in science teaching does not rest solely on the shoulders of teachers, but a successful school program in science education is solely dependent upon what they do with their students. Unmistakably, the teacher is the key!

What Can Be Done?

We have described and interpreted three NSF-sponsored studies on science education to inform teachers and to suggest areas in which they can continue to influence the quantity and quality of science education. We have taken the position that ultimately improvement can stem only from the initiatives and efforts of teachers supported and assisted by local administrative and supervisory personnel. While local efforts will surely have limitations, we believe that much can be accomplished by teachers, administrators, and parents who are committed to improving the science programs of their schools, even in the absence of federal or state funds. This will require leadership, energy, and a clear definition of school priorities. Schools which are not well managed and which ignore the basic precepts of organization and team building are not going to improve their science curricula in any substantial way, even if federal or state funds are available. Federal efforts to support research and development in science education are essential, but we cannot expect governmental support to solve what are essentially local problems.

The studies have confirmed constructive changes in the schools as a result of the infusion of new courses and teaching approaches in the sixties. It is our view that the continuing promotion and support of curriculum development and related teaching innovations by NSF, USOE, and other federal or state funding agencies are essential to consolidate and build upon the accumulated experience and positive changes which have taken place. While these national efforts do not necessarily have to be directed to the creation of complete courses in the PSSC, BSCS, and CHEM Study traditions, much more attention needs to be paid to the creation and trial of methods which build upon the research and development efforts of the past two decades, with emphasis on the use of new technologies such as videodiscs and microcomputers to individualize instruction.

We further believe that more economical and productive approaches to curriculum development and dissemination can be organized at the national level without a loss in effectiveness. We propose that professional science education organizations should assume responsibility for exploring and developing such alternative approaches. For example, the success of the National Assessment of Educational Progress in gaining access to schools—once assurances were given that the results of the assessment would not be attributable to individuals or systems—suggests that a subject matter assessment is feasible. An assessment of the present science content of the school curriculum should be organized and conducted by a team of academic scientists and outstanding science teachers and educators.

A study of this type would be appropriately sponsored by a consortium of disciplinary science societies and their science education counterparts. We envision that NSTA, ACS, AAPT, NABT, and other societies would have major responsibilities. The results of such a study would command immediate attention of teachers, school decision makers, and curriculum planners for much the same reasons that the curriculum reform movement of the 1960s attracted such a ready audience. The science teachers who are most capable of providing school curriculum leadership are the ones most active in the affairs of their professional societies. They are the teachers who want to keep in close contact with the science research community because they find that this contact is intellectually stimulating and enhances their teaching. It is this sense of community, as much as any other circumstance, which made it possible for curriculum reform to proceed as rapidly as it did. If we believe that much of the science content of our secondary school courses (particularly that intended for the student who will not go on in science warrants reexamination, we must turn to the network of school and college science teachers created by the curriculum development efforts of the last two decades.

We have earlier indicated the need for immediate and appropriate assistance at the elementary level. Given the fiscal and political realities of the next decade, it is unlikely that federal funds can be made available on the scale required to provide direct inservice or summer science training to a significant fraction of elementary school classroom teachers. Several alternatives suggest themselves. Federal and state agencies could provide support on a competitive basis to colleges and universities seeking to sponsor special resource-personnel workshops for elementary school team and grade-level leaders whose schools make commitments to organize subsequent inservice training programs using these personnel. These workshops would focus both on subject matter and on classroom techniques designed to enable children, and teachers, to learn science effectively. This form of support is appropriate for federal and state governments, attractive to colleges and universities, and useful for school personnel. Serious consideration must also be given to similar training in preservice programs to avoid perpetuating the problems.

The U.S. Office of Education could earmark funds for state departments of education to award to schools seeking to upgrade elementary school science programs, on a competitive and matching (or in-kind) basis. School systems would be free to specify how these funds would be used in the science program. Options might range from the hiring of science specialists and consultants to the purchasing of laboratory equipment and supplies.

The effectiveness of local efforts to improve science education-on all levels could be vastly increased if the faculties and administrators of schools, colleges, and universities worked together rather than separately. Currently few, if any, coordinated and focused activities exist in science education involving schools and nearby higher education institutions as partners. As an example, funds could be provided to support those proposals developed by teacher-training institutions—in complete cooperation with local school districts—that involve appropriate pre- and inservice training programs in which science teacher training is seen as a continuum, with both groups having important and essential roles to play. Emphasis in such teacher preparation should be on ways to increase openness, flexibility, inquiry, and student involvement.

The NSF/CCSS institutes of the past represented a small but significant step in that direction. Additional models need to be developed and tried. NSTA and similar national associations should lead in stimulating school and college faculties to organize and implement local working relationships which will enable teachers from schools and colleges in a community to know and learn from each other while being constructively occupied with projects designed to accomplish tasks of common concern.

References

Case Studies in Science Education. Volume I: The Case Reports. Robert E. Stake, Jack Easley, *et al*. U.S. Government Printing Office, Washington, D.C. 1978. (stock no. 038-000-00377-1)

Case Studies in Science Education. Volume II: Design, Overview and General Findings. Robert E. Stake, Jack Easley, *et al*. U.S. Government Printing Office, Washington, D.C. 1978. (stock no. 038-000-00376-3)

Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education. Iris R. Weiss. U.S. Government Printing Office, Wash., D.C. 1978. (stock no. 038-000-00364-0)

The Status of Pre-College Science, Mathematics, and Social Science Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies. U.S. Government Printing Office, Washington, D.C. 1978. (stock no. 038-000-00383-6, $3.50)

The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Volume I: Science Education. Stanley L. Helgeson, Patricia E. Blosser, and Robert W. Howe. U.S. Government Printing Office, Washington, D.C. 1978. (stock no. 038-000-00362-3)

The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Volume II: Mathematics Education. Marilyn N. Suydam and Alan Osborne. U.S. Government Printing Office, Washington, D.C. 1978. (stock no. 038-000-00371-2)

The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Volume III: Social Science Education. Karen B. Wiley and Jeanne Rice. U.S. Government Printing Office, Washington, D.C. 1978. (stock no. 038-000-00363-1)

Chapter Two
Science Organizations

American Association for the Advancement of Science

Abstract 55
Introduction 55
Some General Considerations 56
The Social Setting for Education 58
Students 59
Teachers 63
Curriculum 66
Laboratory Instruction 69
Teaching Resources 71
Some Implications 71
Some Action Imperatives 73
Recommendations 75
Appendix 76

National Academy of Sciences, National Research Council

Summary 79
Introduction 80
The Elementary School Curriculum 82
The Curriculum in Secondary Schools 85
Factors Affecting the Quality of Instruction 92
The Current Need 97
Recommendations 98
Implementation 115

blank page

American Association for the Advancement of Science

A Report on the Implications for the Science Community of Three NSF-Supported Studies of the State of Precollege Science Education

Herbert A. Smith*

Abstract

The three NSF-supported studies of the current status of precollege science, social studies, and mathematics education give substantial evidence that serious attention needs to be paid to improving the quality of that education.

Improving quality is not just a matter of developing up-to-date curricula. That was done in the 1960s by various groups with generous financial support from the NSF. But the data in the three reports indicate that the new curricula have not been spectacularly effective. They are viewed by teachers and students as "elitist," and in a sense they are. They were produced at a time when national concern was on producing more scientists—in competition with the Soviet Union—more than on educating all students to understand the natural and social sciences and mathematics.

But the problem of improving science, social studies, and mathematics education is broader than curriculum. Together with all parts of the elementary and secondary school curriculum, education in science is influenced by the school ethos. Lack of respect by students for authority; hesitancy, for various reasons; (including legal), of teachers and administrators to impose discipline; assignment of teachers to subjects for which they are not properly prepared; lack of motivation of students; financial constraints; and many other factors are having a negative effect not only on science education but on education in general.

The findings of these studies lead us to conclude that the time is ripe for an in-depth examination of the goals and purposes of precollege education. We recommend that a commission—similar to the 1893 "Committee of Ten"—of the highest quality and with nationally recognized and respected leadership be established to carry out the examination.

Introduction

This critical, analytical, and interpretive review of three NSF-supported studies of the state of precollege science education was prepared by Herbert A. Smith, Assistant to the Academic Vice President, Colorado State University, with advice from a panel of educators.[1] The chapter examines the implications the studies may have for the science community and recommends lines of action.

Although the three studies were designed to accomplish the same general purposes, they approached the task in quite different ways.[2-8] The Research Triangle Institute study is a report of a questionnaire investigation which collected a massive amount of data from a large number of respondents. The Illinois report is based on a series of case studies involving school systems in eleven different communities. The Ohio State study is an exhaustive review of the available literature on science, social studies, and mathematics education (1,760 individual citations).

Large amounts of data were collected and the reports of the three studies are voluminous. While survey studies provide useful basic data, they, by necessity, report on **what is** rather than on **what ought to be**. The reports are a pioneering effort providing an impetus for many other kinds of studies. Subsequent research efforts can explore implications, carry out experimental research, or in other ways follow up in more detailed and reflected modes on the data made available through survey efforts.

In reviewing the studies, we did not find a certain kind of data that would be helpful in considering the state of science education. The sort of data we refer to is much in demand in service fields, such as agencies that give aid to families or clinics that serve individuals. Usually the data are more readily available in the form of total number of services of a given kind, but not in the more valuable form that allows us to appreciate the distribution of the services to individuals or to families. Consequently it may be easy to tell how much of which service is being used, but not how the services are distributed among the clientele. This latter information may be needed if a vigorous attack were to be mounted on the basic problem. Some individuals may use the service heavily and others not at all, possibly giving a misleading idea of the widespread use of the service.

---

*On behalf of the Panel to Review Three NSF Studies (Appendix).

In the field of education (although in the studies being reviewed we know something about how many courses are given or how many students take a given course, we do not have much information about how many courses in science a student takes. Thus we do not know much about the distribution of science education across students. In a similar vein, we do not know how much science the teachers of science have studied, or what kind. We do not know the distribution of science preparation across the teachers.

It is possible, of course, that these sorts of information are available in other publications, but they did not seem to be present in the studies we reviewed. This is a form of data that would help us interpret current states of education in the sciences.

Because of the open-ended nature of case study reports, the Illinois report is perhaps the most interesting. Nevertheless, there are a number of limitations which seemed apparent to the reviewing panel. There is great variation in the quality of the reports submitted by the field research workers. Some of the observations reported have almost a mirror-like quality that provides the basic documentation for the kinds of perceptions that the observer found worthy to report. At the other extreme, one occasionally finds an instance where a field worker used the opportunity for his own intellectual tour-de-force by digressing into theoretical, philosophical, or speculative side trips without giving the reader sufficient background of specific observations or instances which would lend substance to the arguments. It is perhaps appropriate to mention that, of the several field workers, only one had what might be called a reasonably "typical" background in either natural science or mathematics education. The field workers tended to be highly qualified individuals with evaluation backgrounds. Some had background in the social sciences. No doubt science and/or mathematics educators would have been inclined to report different incidents and perhaps make more valid judgments as to the substantive content of the lessons and laboratory exercises that they might have observed. It is obvious and perhaps inevitable that the different field observers placed their own individualistic stamp in reporting their observations, which also inevitably are colored by their own value orientation and biases.

The purpose of this chapter is to make a beginning at effective follow-up through a reflective commentary on issues raised and to suggest some of the broad implications that the three reports might have for the scientific community.

This chapter has its own limitations and falls short of mining all of the potential implications from the data made available. Because of the scope and extent of the three studies, it was necessary to be selective. The selection process is bound to reflect values and biases of the reviewing panel and of the writer of the chapter, and will certainly reflect their judgments as to what is relatively most important. The panel also recognizes that it is impossible to provide more than a preliminary analysis of many of the issues and problems identified that would be individually worthy of a full-scale monograph in their own right. Still, the panel hopes that it has provided a valuable service in its efforts to prepare a succinct chapter which will be useful to the scientific community in stimulating critical thought and in making the reports more useful in the improvement of science education.

There is no doubt that these reports will provide a data base and a starting point for a variety of studies for many years into the future. There are some inconsistencies among the findings which will serve as an incentive for further investigation. It was conceived to be the function of this review panel to examine the reports in an effort to identify the major issues that appeared to emerge from the studies and to explore what some of the implications of the findings might be. Because it could not do everything, the panel has elected to look primarily at areas of concern that relate to (1) the social setting of education, (2) students, (3) teachers, (4) curriculum, (5) laboratories, and (6) teaching resources. It is obvious that these are not mutually exclusive domains and that to treat them as such is primarily a convenience. There are essential interactions among all of the areas.

Some General Considerations

Before the beginning of a discussion of the specific areas identified above, it seems both appropriate and necessary to provide some commentary about some general problems that seem broadly related not only to these three studies, but to education in general. The studies underscore some of these difficulties. Some explicit examples will make evident why data reported in these studies (and others) need to be used and interpreted with caution. One problem is the use of terms—for example, "science." The three studies are inconsistent among themselves in use of the term "science." At various times it means the natural sciences, or the natural sciences and mathematics, or the natural sciences, mathematics, and social sciences. In general usage, such terms as inquiry, laboratory, grouping, tracking, and inservice education are used to describe a wide array of qualitatively very different activities. For example, the term "inservice education" covers a spectrum of activities ranging all the way from an after-school pep talk by the school principal, to committee work, to travel, to nonrelevant off-campus classes which happen to be offered nearby, to carefully designed local inservice workshops for teachers, to college coursework (any kind), to highly relevant graduate or undergraduate studies or other activities. Thus, when teachers respond to questions about the value of inservice activity it is difficult to determine precisely what it is that they are responding to. Similar statements could be made for other terms used throughout the studies.

A closely related issue is that of "quality." A frequency count to determine how widespread a particular phenomenon may be is, unhappily, no index of its quality. The issue of quality is present in virtually every aspect of education. It is a concern in such diverse areas as teacher-student interactions; the manner of use of laboratory activities and textbooks, or any other instructional material; tests and evaluation; inservice education; administrative procedures; and organizational structure of the school system. The vital question is not only "what," but "how good." The reports of the case study workers (CSSE) sometimes permit inferences to be made of the quality of the activities that they were observing. The Ohio State report on science education called attention to this problem by pointing out that there are substantial data regarding the implementation and **use of** materials but that there are relatively few data on **quality of use.**[9]

Another area of great concern to education is the weakness of its research base. As these studies point out in several instances, there seems to be a lack of general direction, a lack of sufficient background of educational theory that would give direction to and provide the basis for the development of dependable research findings. It is obvious, particularly from the report of the Center for Science and Mathematics Education, that a large proportion of educational research is noncumulative and is often inconclusive or even contradictory.[10] Some of this may be attributable to faulty design, inadequate research conceptualization, or some other factors. However, it seems probable that there are other more general factors involved. Certainly problems of definition and the absence of a substantial theory base are a major part of the problem and contribute largely to the fragmentation and ineffectiveness of much research effort. It might also be conjectured that at least some of the problem is due to the extreme complexities involved in educational problems. For example, in studies of student learning, it might be argued that the impact of any single variable is likely to be very small considering the total universe of variables which affect each student so that significant observable change as a result of the manipulation of a single variable is unlikely. Herein may lie some of the reasons for much inconclusive educational research. It may imply the need for far more sophisticated and comprehensive research designs and far greater precision in identifying, limiting, defining, and measuring research variables.

It should also be recognized that there are large areas that the three reports either do not touch at all or that are touched only tangentially. For example, very little material is presented about individual students. There are repeated references to the lack of motivation, boredom, poor discipline and laziness, but not much information or insight is gained about how the student came to be bored, unmotivated, lazy, or a discipline problem. Little can be learned about individual student aspirations and goals, although some reporting on individual students does appear in the CSSE reports. The student tends to appear as a "collective" rather than as an "individual." Practically nothing is included on student-teacher interactions other than in the formalized recitation-discussion classroom setting. The impacts of the world outside the school—the home, the community and its organizations, its distractions, including TV—are touched upon in a generalized manner, but usually not with reference to their influences on individual students. There are no data, except for a hint or two here or there, about the impact of peer pressure on teachers indicating how they are expected to conform. Very little information is provided about how teachers use their time or how efficient such usages are. The large hiatus with respect to "quality" has already been alluded to. Other examples could be given but these should be sufficient to indicate that, as large and as comprehensive as the reviewed reports are, they leave untouched many questions and concerns which relate to education in the sciences and to education in general. As we have already said, the studies are a pioneering effort that should provide the impetus for many future studies.

The Social Setting for Education

From an analysis of the three reports, one cannot arrive at a very optimistic assessment of the state of elementary and secondary schools in this country. There are serious problems which range in diversity from apathetic, unmotivated and drifting students, deteriorating teacher/administrator/community relationships, major economic crises, poor quality instruction, inadequate equipment and supplies, federal and state regulation and determination of local policies, to widespread community dissatisfactions. Furthermore, there do not seem to be any easy or readily attainable solutions available for many of these problems. The general somber conditions impinging on education today are convincingly reflected in the three reports.

Historically, there has always been a high correlation between the level of education and income as well as in the quality and satisfaction of life which an education tended to ensure. In recent decades, many of these benefits have tended to disappear. Students were quick to point out to field observers that teachers, in spite of all their erudition, were often far less well off financially than either their less well-educated parents or other craftsmen in the community.[11] Thus, students are questioning the economic values of an education. One might look elsewhere for some of the reasons for this view. Undoubtedly the general increases in the standard of living, a narrowing of the income differences between "blue collar" and "white collar" occupations, economic policies, such as the progressive income tax, and the inheritance tax, broad-scale welfare programs, uniform salary and wage scales, and a permissive social climate have all contributed to a lessening of incentives conducive to outstanding performance. One of the field reporters reported teachers' comments as follows:

> *We have lost our work ethic. School is for entertainment. Parents, teachers, and children have lost appreciation for education. They want to be rewarded for performing any kind of work. Rewarding effort no matter what the quality of the product is a part of it.*[12]

This brief quote raises questions about attitudes toward work, the purposes of school, "success" without effort, and the general question of quality. It is a succinct statement reflecting on the malaise affecting both schools and society.

It is impossible to consider the role of the schools as social institutions without thinking seriously about the many outside forces that influence and direct the activities of the school system. One study reported that "schools were the creatures of the social system more than of the Academy."[13] Implicit in this statement is recognition that the public schools are a creation of government and that they are exposed and highly sensitive to the political process. Until about 25 years ago the political sensitivity extended mainly to the local community with some concern for the state level. However, all of this has changed in the last 25 years and now the federal government and expanded state educational bureaucracies assume much larger roles with respect to the operation of schools.

One observer pointed out that the curriculum is definitely a low priority consideration when attention is focused on such matters as minimum competencies in reading and mathematics, desegregation, accountability, and public relations in the community.[14] Clearly, the attention of administrative leadership in school systems today is not focused on curriculum and program development. One observer made the following assessment and provides a rather revealing vignette of the disaster of external intervention:

> *The personnel in the school are under duress. The organization they work in has been severely affected by budget cuts; loss of student population; materials distribution problems; court decisions that enforced the equalization of teaching resources, but introduced guidelines contradictory to those of federally-funded programs; court decisions that forced mainstreaming of all kinds of students; the general poverty and high unemployment rate of the parental constituency of the public schools; the high crime rate, particularly vandalism and theft, that is often counterpart in urban settings of these economic conditions; and by a system heavily dependent on federally-funded special programs characterized by short-term abundance followed by reduction, squeeze-out and pull-out for national, rather than local reasons.*[15]

Whatever may be the merits on philosophical or political grounds of the broad-scale judicial intervention that has occurred in the last two decades, it has created a problem for local public schools. Court-ordered mainstreaming of children with serious behavioral problems has eroded the teacher's authority and reduced ability to maintain classroom control. It is regarded as such a serious imposition that in one case the teachers banded together to petition the union to initiate a class action suit on their behalf to obtain relief. One parent was quoted as saying that "juvenile delinquents are placed in the schools by the courts regardless of their effect on other children."[16] In another school that was under a court order involving desegregation practices, the observer felt constrained to comment that "the school feels it has been left to cope with situations not of its own making, that decisions have frequently been taken on political grounds without reference to what happens in schools." [17] One teacher seemed to speak for many and vented her frustrations in a letter to the local newspaper. She stated:

> *Sometimes, I do think that courts and high officials are trying to destroy education. They certainly put enough stumbling blocks in the path. The officials and legislators here in Illinois are very quick to take a hand in making rules for and demands on schools. These have to be complied with, whether they are educationally sound or not.*[18]

Governmental intervention and the pressure to make the public education system an instrument of social reform have had profound effects on the educational establishment. However successful the various reforms have been in achieving social objectives, the impact of government intervention on the quality of the educational program has been deleterious. Public schools have been substantially reshaped by the social reform efforts.

Considering the impact of government intervention in the schools, it is easier to understand why attention to instructional programs is as inadequate as it is. Real questions appear to be: How can healthy learning atmospheres be created or restored and maintained? How can instructional materials be provided that will stimulate needed intellectual growth in all students and at the same time serve the needs of society?

The educational system is presumably designed for the initial benefit of students, although society expects to ultimately reap a rich return on its investment in the individual. It is appropriate, therefore, that a major section of the report should treat selected aspects related to students.

Students

The three reports provide many details relating to the students and their relationships to the educational establishment. In a careful review of the materials there are a number of recurring themes and problems which seem to emerge and which merit attention in this review.

Motivation

One of the most persistent themes reflected throughout the reports of the field observers is that average and below average students are not motivated by their school programs. Even those upper ability students who are generally reported to be receiving good grades and to be doing reasonably good work are apparently motivated by the desire for good grades rather than to achieve intellectual goals.[19] There is also evidence of an "avoidance syndrome" of rigorous courses by grade-point conscious students, sometimes encouraged or advised by counselors.[20] School, too often, is seen by students as a necessary evil—a sort of waiting period before they can get on to the really important things in life, like going to college or getting a job. There is little evidence that getting an education is regarded as a privilege, as an opportunity for personal development and enrichment, to be cherished in its own right. Although schools have not historically been known as beloved institutions by generations of students, it seems that the present generation of students reflects a deeper and fundamentally more serious negativism toward schools, teachers, and education in general. The indicators of such negativism are numerous and, in addition to lack of motivation, include the continuing references in the reports to boring classes, vandalism, disruptive school behavior, and pervasive anti-intellectual attitudes.

As indicated earlier in this report, while the conditions stated above are well documented in the studies, there is very little that relates to their etiology. What are the conditions—educational, social, psychological, economic—that develop these unsatisfactory attitudes in many children and adolescents? How have homes, schools, and society in general failed such children to such an extent that they become dropouts from learning and problems both to themselves and to the larger social order? What changes have occurred in the social system which account for such shifts in student attitudes and behavior? Even students who do well in their work often appear to be working for external reasons. They are concerned about grades and passing tests. The question "Will it count?" is all too familiar to teachers.

It is hard to escape the conviction that many, perhaps most, students do not really have a commitment to education nor do they feel any internal, intrinsic need for self-fulfillment through educational accomplishment. The social turmoil of the 1960s, which was an outgrowth of the Vietnam conflict, had a very profound effect on the young which still persists. Student activism successfully challenged established authority and standards in a wide range of actions.

The question of how to motivate students will continue to be one of the most perplexing problems in education and one which appears to be in obvious need of further research and analysis as well as action programs designed to recapture and redirect student motivations.

Achievement

Although assessment of student achievement was not a major focus of the studies, concern over poor achievement is reflected repeatedly by references to unmotivated and apathetic students. A quotation that catches the spirit of this concern states:

> *. . . in every site teachers, administrators and parents were saying that the children have changed. In many respects they do not like the change. . . . Each generation clearly sees that the younger folks do not work as hard as they did. And now children are seen to lack motivation, concern about the future, and respect for authority. "They think too much about cars. They go off around the world. They don't settle down to a real job." Teachers are as dismayed by this view as other adults are.*[21]

There is substantial evidence in these reports as well as from other organizations, particularly the National Assessment of Educational Progress and the College Entrance Examination Board, to support the position that standards of achievement have been falling steadily over the past decade or so. This includes students at all levels, including the college bound. Although there have been many attempts to explain away this finding, the evidence appears to be convincing that the decline is real. The complaints of teachers relating to student performance are numerous and among others include the allegation that things must be taught over and over again. There also seems to be evidence that learning fails to transfer efficiently. Obviously these are not new problems, but they seem to be present in a more pernicious form than formerly. One would be inclined to ask whether or not teaching is less efficient than it used to be, whether there are new conditions or influences that adversely affect learning or whether students on the average are less capable than former generations of students.

Students appear to take a very short-range view of the value of education. Perceptions seem to be that knowledge should have immediate application or should clearly relate to job opportunities. Such a view tends to fly directly in the face of intuitive knowledge that what seems highly relevant to one who is 12, 16, or 18 years of age is likely to have been proven invalid by the time one has reached middle life. In spite of this, courses that do not provide education that is easily identified with specific job preparation including science, mathematics, and social sciences are called upon to justify their continued existence in the curriculum. In brief, education seems caught up in the issues of general education versus vocational education, short-range versus long-range goals, and economic versus humanistic considerations.

It seems both unfortunate and incorrect that sciences are perceived to be relevant only for those who are to become top flight professionals. It is not perceived to be significant in the daily lives of average citizens. A comment by a student clearly reflects this ubiquitous view.

> *When you* do *get into higher math and science stuff, sometimes you feel unless you're really going to continue and be a physicist or something, there's no reason to take it because you're never going to use it. Unless you're really planning on climbing the ladder and be way up there. It's practical to stop.*[22]

Additional comments on the general educational functions of science are included in the section on curriculum.

Learning

Although the areas of curriculum and teaching will be considered in later sections, it is useful at this point to point out some of the interactions that students have with both curriculum and teachers. The evidence from these studies indicates that the NSF curriculum reform movements of the 1960s and particularly those in mathematics were not very successful. The several projects are perceived to be elitist in character. One field observer commented:

> *It is perhaps important to note that where the curriculum reforms of the Sixties found their main*

audience, and made their greatest impact, was on high status, high income, middle class school systems (witness PSSC, Chem Study . . .). These were, after all, innovations that belonged primarily to elite groups: to the universities, the foundations, a few exceptional schools.[23]

The reform efforts tended to emphasize the structure of the discipline, in-depth learning, and laboratory activities requiring considerable thought and insight. To students who are now looking for "relevance," fulfillment of immediate objectives, job-related learnings, and practical applications of science to technology, the new curricula have little appeal. When these rigorous curricula are placed in the prevailing school and community context and when all the handicaps related to facilities, teachers not prepared to use the curricula, disciplinary problems, and the governmental requirements discussed earlier, it is not hard to understand why they are having limited success.

The hypothesis that any subject can be taught effectively in some intellectually honest form to any child at any stage of development provided the psychological support and rationale for curriculum reformers to introduce more abstract and difficult materials at lower grade levels.[24] It is difficult to establish a firm connection between such a psychological concept and some of the content in the new curricula, but it seems reasonable to speculate that this view contributed to the limited success of some of the new programs. Teachers interviewed in the case study reports had very different notions about what might be appropriate for children.[25] One teacher commented:

Earlier and earlier we expect more and more. Where will it end? We pay for it earlier and earlier, too. Scandinavians do not start their children until age eight. Their literacy rate is better than ours. In two years their children are caught up with their European counterparts.[26]

The dichotomy between students' expectations and the goals of the curriculum reformers has already been pointed out. However, it seems possible that some of the present student disenchantment, their lack of motivation, their boredom, and their lack of effort may be related to the fact that the curriculum content is not really suited to their level and that it is indeed too difficult and too abstract for most of the students. This may imply, too, that learning theories derived from carefully controlled and ordered laboratories do not necessarily have relevance in the kinds of social settings prevailing in most schools where discipline concerns, peer pressures, and many distractions all operate to undermine the effectiveness of the learning process.

In another comment related to student learning, CSSE reported that much of the instruction observed could be characterized as molecular rather than holistic.[27] This is a key observation and is probably related to a number of problems including the misuse of teaching materials, lack of transfer of learning, and dull and unstimulating instruction. "Big ideas" are more likely to be retained by students than isolated facts. However, many of the examples of instruction that were reported in the CSSE study seemed to be emphasizing factual information without placing it in the context of larger conceptual schemes. When learning is not placed in such an overall structure and when it is not personalized or related meaningfully to the experiential background of students, it is unlikely that it will be long remembered.

Discipline

Discipline in the public schools has become a serious problem. It is referred to frequently by the field observers. One individual reported:

The major obstacle [to sound instruction], it often appeared, what [sic] works against these efforts to be efficient and effective, was the student. Not just his poor background, but his lack of commitment to learning, his distractability, his defiance of authority,—hers too, of course. And these obstructions are not neatly contained so as to obstruct only the learning opportunity for that learner, but spill over to impede the whole class. The teacher looks for ways of intimidating or cajoling, often without success. The teacher seeks to isolate or expel the misbehaving student, often without success.[28]

The historic conception of the schools as being "in loco parentis" has disappeared. The general ambience of a permissive society has made the problem of control of students extremely difficult. Discipline in some schools has become such an acute problem that it seriously interferes with the academic program. It is a source of teacher frustration and tension and may be part of the explanation of why standards have fallen and achievement scores have declined.

The erosion of the school's authority has not passed unnoticed by the students. They have demanded and received rights and privileges which in earlier days would have been denied. Whether these greater freedoms have enhanced the educational achievement of children and youth is doubtful. That it has contributed to the difficulties and frustrations of maintaining a sound learning environment is scarcely to be denied.

As a further index of problems in this area, the field observers reported high rates of absenteeism, students wandering the halls, and a flagrant example of student disrespect for the teachers' authority. Although not reported in these studies, actual physical abuse of teachers has occurred on a fairly wide scale. Verbal abuse of teachers is a daily occurrence in many schools.

Such counterproductive conditions should certainly not be allowed to continue to prevail. It is a major educational problem when in the name of freedom and individual student rights, conduct must be tolerated that adversely affects the learning environment to the detriment of students who really wish to learn.

It seems clear that the notions of freedom and individual rights for students have often been extended far beyond any reasonable limits and as a result have often seriously impaired the ability of the schools to maintain an atmosphere conducive to effective learning. It seems clear that such freedoms are neither in the best interests of students nor of society. There is also a question of the rights of teachers to be accorded the respect, dignity, and consideration to which their office should entitle them. A recognized world authority on learning has made some pertinent observations about the impact of excessive freedom for students in the educational setting.

Is the free and happy student at least more effective as a citizen? Is he a better person? The evidence is not very reassuring. Having dropped out of school, he is likely to drop out of life too. It would be unfair to let the hippie culture represent young people today, but it does serve to clarify an extreme. The members of that culture do not accept responsibility for their own lives; they sponge on the contributions of those who have not yet been made free and happy—who have gone to medical school and become doctors, or who have become the farmers who raise the food or the workers who produce the goods they consume.[29]

The natural, logical outcome of the struggle for personal freedom in education is that the teacher should improve his control of the student rather than abandon it. The free school is no school at all. Its philosophy signalizes the abdication of the teacher. The teacher who understands his assignment and is familiar with the behavior processes needed to fulfill it can have students who not only feel free and happy while they are being taught, but who will continue to feel free and happy when their formal education comes to an end. They will do so because they will be successful in their work (having acquired useful productive repertoires), because they will get on well with their fellows (having learned to understand themselves and others), because they will enjoy what they do (having acquired the necessary knowledge and skills), and because they will from time to time make an occasional creative contribution toward an even more effective and enjoyable way of life. Possibly the most important consequence is that the teacher will then feel free and happy too.[30]

Peer Pressure

The fact that the majority of teenagers do not place a high value on education has penetrated deeply into the teenage culture. Although the studies do not refer pointedly or frequently to this problem, evidence of its existence does show up in a few instances.

Although the adverse impact of these pressures is probably greatest on minority children, on children of poverty, and on children from lower-class homes, all children are subject to peer influences. It is notable that the references to the peer pressure problem in the studies pertain in every instance to children who are either minority or with low social status. In one instance the observer reported that "the cost of being interested in education and valuing what the school has to offer is that it had cut Helena [the student] off from the social life that permeates school for most students." [31] In another instance the reporter stated, "They call Carmen 'Jaitona' (snotty) and other names." [32] In still one more instance, it was stated of students in a ninth grade class, "some who aren't so bright and others who are bright are so heavily into the 'street' system of social relations and so under peer-dominated social control that they are lost to the activities of the classroom." [33] In the case of both teenage girls mentioned above, they were minority students. These incidents reflect the considerable social pressures exerted on such children in trying to ensure their conformity by nonachievement. The price of academic success was ostracism by their peer group. Few children have the strength of character and the sociological and moral supports to withstand this kind of pressure. Thus, a major problem appears to be how one might reorient the peer group (a difficult task) or, alternatively, how one can help such students to maintain their goals and aspirations and to protect them from the sometimes rather savage assaults of their peers.

The pressure of conformity by peers is also illustrated through another incident reported in which a student made an unorthodox but not necessarily incorrect response to a teacher's question. The student was ridiculed and laughed at and even though the teacher in this instance had regarded it as a "beautiful" and creative response, he did nothing to protect the particular individual from being embarrassed by his peers. It might be argued that it is a reasonable responsibility of the teacher to look for the rare, creative, and insightful response and to rise quickly to the defense of students who make such responses and thereby create a climate in which "the unorthodox" idea can not only be stated, but be encouraged.

Teachers

The heart of the instructional process is the teacher. In emphasizing the importance of the teacher, one worker made the following observation:

Teacher Is Key. *What science education will be for any one child for any one year is most dependent on what that child's teacher believes, knows, and does—and doesn't believe, doesn't know, and doesn't do. For essentially all of the science learned in the school, the teacher is the enabler, the inspiration, and the constraint.*[34]

It is an irony of education that when teachers were regarded as low-paid menials their control over children and the educational process in general was almost absolute; yet, as teachers have approached a more nearly true professionalism, the controls teachers may exercise over students particularly, and to some extent over curriculum and teaching materials, has been gradually eroded. Teaching today is not a particularly happy occupation and any observer of the profession over a period of time is continually distressed by the exodus of many fine teachers to other occupations. Yet this is not surprising when one considers the frustrations that teachers must endure in the present educational setting.

Teachers encounter pressures from all kinds of special interest groups and parents. There are demands for accountability, teacher evaluation and voluminous records and reports. Additional problems include inadequate materials and supplies, poor maintenance for equipment, and insufficient time to accomplish all of the assigned responsibilities. Considering all of these many factors it is no wonder that teachers are not highly enamoured of many of the curricular innovations that are presented to them. No wonder, either, that teachers are occasionally hostile toward "scholar's help." [35] In spite of all these problems, however, there are many excellent teachers who can and do conduct first-class educational programs. Unfortunately, their number is insufficient.

Teacher Assignment and Misassignment and Related Problems

The studies provide some insight into one of the most grievous problems in American education. It is also one that gets some of the least exposure. This relates to the assignment of teachers, particularly at the junior and senior high school levels. There are assignment problems in the elementary school but they are of a different order. With regard to secondary school teachers, one hears a great deal about the poor teacher preparation encountered. If one probes beneath the surface, however, the problem is often not lack of preparation but of misassignment. The data reported in the three studies give ample evidence that misassignment is a very real problem and a common phenomenon. That there are administrative problems in making appropriate teacher assignments cannot be denied. There is always an overflow section of English, algebra, American history or other subjects that have to be taught. Nevertheless, there are too many instances where teacher assignments do not reflect this kind of administrative necessity but, rather, result from inept recruiting, poor management, lack of planning, or other extraneous factors.

The problems are now intensified because many schools are faced with reductions in force, and retention and reassignments are made on the basis of seniority rather than on curricular needs or professional qualifications. One teacher reported that half of the mathematics teachers in his school were really social studies teachers.[36] In other instances, the intent of affirmative action seems clearly to be circumvented and a field observer reported that in certain sites they found "kith and kin" considerations to be highly significant in teacher employment. Somehow or other it seems that this type of provincialism should be passe.

Evidence presented in the Research Triangle Institute study indicates that in the junior high schools only 28 percent of the mathematics teachers, 24 percent of the science teachers, and 24 percent of the social studies teachers had teaching assignments restricted to these fields only. The comparable figures for senior high schools were 27 percent for mathematics, 27 percent for science, and 31 percent for social studies teachers.[37] Unfortunately this information is not very useful since no evidence is provided about teachers' academic and professional preparation. It may well be that they have teaching assignments in mathematics only and yet be minimally prepared in the field. The presumption probably is that most of these people were teaching in their major field but there is no evidence submitted to demonstrate that this is, in fact, so. It is certainly well known that a great many teachers are teaching outside of their major fields of preparation. Perhaps the most important question is not whether they are teaching in more than one field, but rather how adequate the preparation may be to teach whatever it is that they are assigned to teach. There might be a reasonable expectation, for example, that a physics teacher would be competent to teach an introductory algebra course.

It is perhaps significant also to point out that only somewhat over 5 percent of school principals have backgrounds in mathematics and approximately 10 percent have backgrounds in natural science.[38] This in itself might give some clue to the lack of emphasis or focus in many schools on academic programs, including those in science and mathematics. It may also raise serious questions about communities' values and the relative values they assign to academic programs versus other school activities.

Preservice Training of Teachers

None of the studies gives much information about the preservice training of teachers although they tend to emphasize that, especially in the 1960s, attention was focused on inservice education to the neglect of preservice concerns.[39] This appears to be one of the major gaps in the reports. Yet good preservice programs are the best insurance for qualified teachers. It is much more difficult to correct deficiencies, particularly in the academic backgrounds of teachers once they have been certified, than it is to require adequate preparation prior to certification.[40] As previously indicated, the quality of much that passes for inservice education is of dubious value and is hardly likely to compensate for major deficiencies that may exist in the preservice program. Although accreditation standards of various kinds have helped to ensure some measure of quantitative control—specific courses, number of credits, etc.—accreditation rarely touches upon the qualitative aspects of programs either in the content teaching areas or in the professional educational components.

Although many criticisms have been made of teacher preparation programs, the facts are that almost no major teacher preparation institution would graduate and recommend a social studies student for certification as a teacher who did not have a broad background in the social sciences including the equivalent of a major in one field with supporting courses in such areas as geography, sociology, economics, and political science. If the major should happen to be in one of these fields, then substantial work in American history and a selection of non-American history courses would be required. Similarly in biology, a teacher recommended for certification would typically have a sound grounding in botany, zoology, and physiology, with required courses in genetics, organic and inorganic chemistry, microbiology, etc. Other fields tend to show a similar pattern with adequate distribution and depth in appropriate courses, at least to the extent that such distribution and depth can be acquired in a four-year baccalaureate program of studies. It must be reiterated, however, that no preparation program can compensate for faulty teacher assignments.

Probably one of the most serious preservice problems in science relates to the preparation of elementary school teachers. Elementary school teachers are reported to indicate that they have the greatest feelings of inadequacy with respect to teaching science.[41] This is surely partly a reflection of their preparation. Often as few as six hours of science may be required, which is likely to be a general survey type of college course or the introductory courses in a major field. However, the number of hours is not necessarily an index of quality. College science courses provide practically no preparation of the kind that would be useful to the elementary teacher in the classroom. The professional preparation component of the teacher's education tends to focus heavily on the teaching of reading and mathematics, especially reading. Professional preparation to teach science may be minimal. The AAAS, in cooperation with the state directors of teacher certification, has been active in addressing the problem of teacher preparation.[42]

The Ohio State University study reflects some serious problems with respect to junior high school teachers. Few teachers prepare specifically to teach junior high school science. Most junior high school science teachers have been prepared to teach senior high science and thus have specialized in biology, chemistry, or physics. Junior high science is usually a mix of disciplines. Ideally it should address the unique psychological and social needs of early teenage children and junior high science teachers should be specially prepared for this important task. Preparation programs focusing particularly on teaching at this level are comparatively uncommon, although there has recently been some enhanced interest shown by teacher-preparing institutions. The Ohio State report indicated that in 1968 there was a lack of basic objective evidence on the effectiveness of teacher education programs.[43] This situation still prevails. There is no doubt whatever that many institutions of higher education have teacher education programs but do not have either the commitment or the resources to prepare quality teachers.

In the senior high school it appears that problems at this level, as far as formal preparation is concerned, are much more likely to be identified with the misassignment of teachers than with the formal preparation in their specialized subject field. The same questions of quality and relevancy of the typical academic major to the realities of teaching in secondary schools still prevail.

Another issue that needs to be faced squarely is the relationship between the amount and quality of the teachers' professional and academic preparation and the performance of their students. The small amount of evidence submitted in these studies is not reassuring. It was indicated that neither years of experience nor advanced training was significantly related to differences of frequency of use of good reading practices.[44] In another instance it was reported that research workers "found that there was no correlation between formal subject-matter preparation and teacher knowledge of the subject or between formal subject-matter preparation and student cognitive learning." [45] In reviewing the research on mathematics teachers and the results of some major studies, it was reported that "the teachers' characteristics did not account for a significant portion of the variance" [46] (in student performance) and there was "no significant correlation between teachers' knowledge and performance of their students." [47] Such findings raise serious questions about the nature of both preservice and inservice training programs and about both the professional and academic components of preparation. There are certainly a number of alternative explanations that might be considered in exploring this phenomenon if further evidence establishes its general validity. It may be that once a minimum competence in subject matter is attained, other abilities such as those pertaining to communicator, facilitator or motivator roles may become more important. Thus a minimally prepared teacher might be equally or more successful than a colleague with more substantial academic preparation who lacks personal qualities or traits useful in the classroom. Or it may be that teacher preparation is such a minimal factor in the psycho-social setting of the school that it contributes relatively slightly to the total variance in student performance. Still a third possibility is that preservice and inservice programs are just not relevant in terms of the selections of subject matter and methodologies that are appropriate to elementary and secondary school teachers' needs. Whatever the case, it would appear that this is a major problem and one deserving of some serious exploration by research workers. Obviously, the debate and concern about both pre- and inservice education for teachers can be meaningful only in the context that such training does make a difference in the learning and performance of their students.

Inservice Training of Teachers

The concept of inservice education covers a broad spectrum of activities that vary greatly both qualitatively and quantitatively. The report from Ohio State University states, "inservice education appears to mean different things to different people, with little agreement concerning its purpose." [48] One of the criticisms teachers make of inservice education is that it is not "job specific." Locally designed inservice programs for the purpose of introducing a new curriculum might very well be highly specific job-related learning.

On the other hand, graduate courses at a university are presumably looking at broad concepts, principles, and problems in the field. They should be useful to the teacher, but in a more general sense. They would require translation, adaptation, and filtering to make them applicable to the specific needs of individual elementary and secondary classrooms. A professional teacher should be able to make such a translation.

In general, the teachers surveyed felt that the National Science Foundation institutes were moderately successful to successful.[49] There is a tendency to lump all of the NSF institutes into a single stereotyped category in the studies. Like other stereotypes, this is subject to question. Undoubtedly the institutes varied enormously in their quality and value. There is not much doubt that teachers would like to see them continued, although there were occasional criticisms of the programs. One cannot avoid considering the possible self-serving motives involved in the positive evaluation made by many teachers who hoped that good ratings might encourage reestablishment of the programs.[30]

One of the criticisms of the institute program was that generally they tended to serve teachers who needed inservice training least.[31] On the positive side, the institutes served a very large proportion of the present leadership cadre in science education and provided them with experiences and perspectives that they would otherwise have been unlikely to acquire.

Curriculum

The last twenty-five years have witnessed unprecedented activity in the field of curriculum development. The aftermath of World War II, Sputnik, the Cold War, the support by the federal government of various curriculum reform endeavors—with generous support of many millions of dollars—an accelerated rate of technological development, student activism, and various aspects of social reform have profoundly influenced the curricula of the schools. School curricula have been influenced by currents and counter currents including liberal and conservative ideologies, innovators and traditionalists, accountability adherents, promoters of management by objectives, elitist versus populist philosophies, and advocates of technological applications to education. Considering all of these forces seeking to change the educational curriculum, there is not much wonder that the school curriculum sometimes appears to be in disarray.

Curricular Innovations

No period in American history has witnessed the introduction of so many educational innovations, particularly in science, social studies, and mathematics, as the last twenty-five years. There are those who feel that the innovations were introduced with "insufficient rationale for sweeping changes in curriculum and instruction."[32] One of the problems has been the definition of "change." Change may be revolutionary—change with a capital "C"—or evolutionary—change with a small "c." Even the most conservative educator recognizes that neither curriculum materials nor teaching practices can maintain a **status quo** position. Improvements are always needed in education. But, as the Ohio State University review indicates, there is a feeling that "far too many of them [new instructional approaches] have been promoted as panaceas, rather than as components in a teacher's repertoire, to be used as children, content, and circumstances warrant." [33]

"Reform" Efforts Supported by NSF

The reform programs sponsored by NSF have been perceived by some to be in the elitist tradition. They reflected a philosophical position that science is an investigative and logical search for order and that content should be selected and instructional materials developed in accordance with this concept. They were difficult and they were demanding on both teachers and students. The emphasis was on structure of the subject matter and much of the content was abstract, perhaps most markedly so in the so-called "new mathematics." However, the NSF-supported reform efforts started just before or just after the launching of Sputnik in 1957 and were a response to the concern that the United States needed more scientists to compete with Russia. The new curricula were conceived of as elitist. Then in the late 1960s and early 1970s national concerns were refocused on such things as relevance, job-related learning, consideration of opportunities in science for all members of society, and limitations and problems of technology. These "deficiencies," evident in the reports, do not reflect on the purpose of the NSF-supported curriculum projects, but rather on the change in direction of the purposes of elementary and secondary science, social science, and mathematics education.

The NSF-supported curriculum projects have had a strong positive effect on precollege education. Perhaps the greatest value is in the influence that they have had on instructional materials produced by publishing companies. It is probably the case that commercial materials have been substantially improved either through the need to compete more favorably or through emulation, imitation, and/or stimulation provided by the NSF-sponsored materials. No doubt certain materials and practices were also avoided on the basis of observations of problems with the project materials. Such influences will probably continue for many years into the future.

Elementary School Science

Many factors have converged to contribute to a diminishing role for science and social studies in the elementary school. After the flurry of activities to promote science and social science education in the elementary schools during the 1960s, there has been a gradual decline in emphasis and time devoted to the subject.[34] Factors contributing to this situation are numerous and include the inadequate preparation of elementary teachers in science and the decline in student achievement which further stimulated the very strong "back to the basics" movement along with demands for accountability and competency, especially with regard to reading and mathematics. The view is widespread and supported by junior and senior high school science teachers that perhaps science is really not very important in the elementary school.[35] One thing that is not clear from a philosophical point of view or from any evidence included in the three reports is why science vocabulary, facts and elementary ideas, and concepts of science cannot be used as a vehicle for the reading process and for correlation with school mathematics. This is a point that deserves serious consideration by school systems and other groups concerned with the quality of precollege science, mathematics, and social science education.

The reports indicate strong negative reactions by teachers toward the moving down of difficult materials from higher grades into lower grades. They resist the notion that better instruction means harder instruction and by implication they see such efforts as only increasing their difficulty in keeping students motivated and responsive to the instructional process.[36] This is another point that should be considered seriously. Is the implication justified? Do teachers need inservice orientation?

The "back to basics" movement is a fundamental determinant of elementary school curriculum today. By some, science and social studies are not included among these basics, although why they are not is a pertinent question. Scientific concepts such as time, distance, gravity and life-maintaining requirements of the living organisms are among the most basic ideas that one can imagine. The fact that natural science is not considered a "basic" is probably a reflection of some of the misconceptions held about the sciences by society at large.

"Back to the basics" is supported by some teachers who appear to be convinced that improvement in science education and in other fields is directly related to reading ability and ability to do mathematics. It is hard to fault teachers for such a view since reading and mathematics represent enabling skills basic to all other scholarly attainments. Very often the skill of writing tends to be omitted in the modern concept of "basics."

Reading must have some content and it is hard to understand why some reading content cannot be based on science.

One of the interesting ideas that emerged from the case studies report was that **inquiry** does not appear to [be] **work!** [37] Anyone who has ever engaged in serious inquiry realizes that nothing could be further from the truth. How, then, does such a perception emerge? Possibly it may be a reflection of the poor use of inquiry techniques as they were observed in the cooperating schools. It may reflect the poor discipline or at least the considerable disorder that sometimes prevails when students are involved in inquiry-type lessons or it may merely be that productive activities were in progress which were not readily discernible to the case study observer. Perhaps students were having "too much fun." Whatever the explanation might be, it is unfortunate that such a view prevails and it gives credence to and support for more low-level drill type activities which underlie a "basics" philosophy. There seems to be common acceptance of the notion that **hard work** is **good work**. It may, in fact, be nothing of the sort. While it certainly is legitimate for the schools to emphasize that outstanding achievement requires hard work, there seems to be a transformation of this idea to the unacceptable notion that "any hard work is good work." [38]

Secondary School Science

Secondary school science education seems to lack a sense of direction and a theory and philosophy which should provide guidance to curriculum development and instruction. This may, in part, reflect the "elitist" philosophy of the curriculum development projects of the late 1950s and early 1960s. In reference to the natural sciences, the reviewers at Ohio State University stated that in their opinion "it appears that the role of science in the secondary school curriculum for general education remains unclear. What science students should learn also remains unclear." [39] The panel who advised the writer of this report concurs with this observation, but suggests that it may have applicability beyond the natural sciences and that it is time for the development of a coherent philosophy and the establishment of directions for all science education.

It seems doubtful that there has ever been a time in which there was so much uncertainty about the purposes of education. What constitutes an appropriate general education for all seems now to be an unpleasantly obscure question. The purpose of education has been explored from the times of the ancient Greek philosophers down to the present time. Herbert Spencer's essay "What Knowledge Is of Most Worth?" explored the topic.[40] More recently, the Educational Policies Commission of the National Education Association has issued statements relating to the general purposes of education in American society. Although such statements may still be valid, they no longer serve as guides and compasses. The three studies suggest that now is the time to look sharply at the purposes of education to our society and particularly to the role of science, mathematics, and the social sciences in the education of American citizens.

The curriculum projects of the 1960s, for reasons made clear earlier, did not address the problem of general education.[61] One of the strongest criticisms made by the reformers of the then existing science programs was that there was too much emphasis on technology. It was their contention that what was really needed was more attention to "pure" science. In their view, this was urgent because of the Russian success with Sputnik and the general high level of Russian technological advances. What they were interested in was training high grade professional scientists who could advance technologies related to nuclear energy, space exploration, oceanography, and so on, that would enhance defense systems and national security.

The new science curricula funded by NSF did not address technologically based problems or the problem-solving techniques necessary for developing solutions. Students did not learn of the relationship between science and technology, hence as future citizens they were unaware of the roles that research and development play in an industrial nation and the trade-offs and side effects that would affect them individually and collectively. These were not a part, nor were they intended by the curriculum developers to be a part, of the curriculum developments of the 1960s. Clearly, future curriculum developers need to be concerned about introducing social implications of science into the secondary school curriculum.

Course Sequences

There is no generally recognized sequence of courses at the junior high level in any of the science fields. At the senior high level, the sequence of biology, chemistry, and physics seems to be rather firmly fixed in the natural sciences but tends to be restricted to the group of students bound for college. For the non-college bound, biology is typically the last and only science taken at the upper secondary school level.

Both junior and senior high schools most frequently offer American history, although the content is sometimes included under the general rubric of "social studies." Other social science courses most commonly offered in the senior high school are world history, American government, and sociology.

In mathematics a fairly definite sequence of 7th and 8th grade mathematics, 9th grade (in some cases 8th grade) algebra, 10th grade geometry, 11th grade advanced algebra, and 12th grade advanced mathematics (trigonometry and calculus in some cases) can be identified for college preparatory students. Many other kinds of mathematics courses are also offered for students with different objectives.

In large school systems all three subject areas are represented by a variety of elective courses which may reflect accommodation to either low or high ability students, specialized academic or vocational interests, or the use of local specialized resources. Electives include such courses as physiology, astronomy, zoology, advanced biology, and advanced chemistry among others in the natural sciences; black history, law, economics, geography, and psychology among others in the social studies; and probability and statistics, computer mathematics, and business mathematics among others in mathematics.[62]

The Articulation Problem

The problem of what ought to be taught, to whom, and when, is one of the chronic dilemmas of education. Fitting a twelve-year educational program together so that the basic facts and concepts come in an appropriate sequence is the problem of articulation. The evidence submitted in the three studies reviewed indicates that articulation problems are widespread.[63] Schools have apparently not succeeded well in developing a coherent, articulated program of instruction. Articulation is most pressing in a highly ordered and sequential field such as mathematics. It is less so in science and still less so in the field of social studies. Nevertheless, there is a need and a value of sequencing even in a less structured field such as social studies since instruction can be more efficient and more can be accomplished. Students also have an equity in articulation because of the difficulties which they may encounter when they transfer between schools, or between school systems, and find themselves placed in classes for which they do not have adequate preparation. Obviously there is a need for articulation between grade levels.

Some of the factors contributing to poor articulation include the autonomy, interests and qualifications of the individual teacher, nonsequential instructional materials, lack of communication between teachers and between educational units, particularly between the elementary school and junior high school and between junior high and senior high schools. Failure to solve these problems results in students who complain bitterly that they have had the material before and they find it boring and unmotivating, or that they are lost because they do not have the needed background. Teachers often counter with the observation that they may have had it, but they did not learn it, or conversely, that they must catch up.

There are curious inconsistencies with respect to the problem of articulation. Teachers have a disposition to "cover the material" and to justify their work as preparation for work to be taken in subsequent grades. Strangely enough, teachers in these subsequent courses seldom believe that the material has been thus; although there is a widespread "preparation ethic" it does not seem to be consistent with the apparent widespread lack of articulation.

Textbooks

One of the field workers (CSSE) pointed out that the heart of the instructional process is in the instructional materials.

Behind nearly every teacher-learner transaction reported in the CSSE study lay an instructional product waiting to play its dual role as medium and message. They commanded teacher's and learner's attention. In a way, they virtually dictated the curriculum. The curriculum did not venture beyond the boundaries set by the instructional materials.[44]

In the great majority of cases, the instructional materials are provided by the textbook. Despite the lamentations of academicians, professors of education, curriculum developers and others about textbook-oriented instruction, the practice has continued to prevail and flourish. When a practice continues so long in the face of long-standing and severe criticism by outstanding educational leadership, it may be desirable to examine the practice in considerably more detail. Why have textbooks had such an enduring quality in the educational process?

From the teacher's view there are a great many positive aspects to the use of a textbook. A textbook provides a structure and an outline of content. As indicated in the section on teachers, time is indeed a precious commodity and teachers never have enough of it. The textbook makes minimal requirements on the teacher's time, provides a base reference for course requirements which must be met by students, and minimizes the teacher's need to prepare special handouts or other types of instructional material. Its use is expected by parents and community, and it is not likely to be questioned as to authenticity or appropriateness. In short, teachers look upon the textbook to provide structure, continuity, and a reasonable selection and boundary of the content which should be taught and as a backstop for questions that may be raised by school patrons. Packet and loose-leaf materials, teacher-made materials, etc. are far more difficult to keep organized. They increase still further the demands on the teacher's time through greater bureaucratic and administrative duties. They also require adequate support staff (clerks, secretaries, aides) which is often not available. If this is a reasonable analysis, then perhaps it is appropriate to look at the manner in which textbooks might be used more effectively since it appears that they will be a fixture in education for a long time.

Many of the historical criticisms that have been made of textbooks have related more to the manner in which they have been used than to the textbooks themselves. Very often textbooks have been used in a manner never intended by the author. They have too often been used in a catechetical fashion rather than as a dependable source of information for use as a point of departure for further interesting discussions or other follow-up activities. They have often been used as a basis for rote learning with the result that instruction has been barren and dull. Too often there has been a lack of application of textual materials in ways which are meaningful to the students. The instruction has not been personalized, embellished or embroidered by additional examples or illustrations which could be related to the individual lives of students. Thus, it is a logical conclusion that if the textbook is to remain as a central feature of the educational process, strenuous efforts are needed to make the use of such an instructional resource far more effective than it has often typically proven to be.

Laboratory Instruction

One of the insightful paragraphs in the case studies related to the changes which have occurred in the concept of what constitutes laboratory work.[45] It is pointed out that the new science topics in the curriculum create problems for laboratory and demonstration work. Many of them do not lend themselves easily to the traditional formula which required the arrangement of material or equipment, the observation of phenomena, appropriate recording of observations, interpretations, conclusions, etc. The observer pointed out further, that such activities as working with structural models of molecules, studying ecosystems in the field, maintaining a balanced aquarium, developing a film or prints and constructing an electronic circuit, all lack adaptability to the ordinary "formula" of laboratory instruction. This observation prompted a reporter to ask "If the format changes to accommodate these interests, then where is the rigor of scientific method?"[66]

As part of the intellectual revolution which the curriculum reformers of the 1960s were seeking to promote in the science curricula was an emphasis on the processes of science. Students were to experience those processes primarily through discovery techniques usually labeled as "inquiry." If these three studies are any indication, quality inquiry-type instruction is a rare occurrence. Testimony seems to indicate that only the most gifted students are able to profit from this type of an approach to any considerable extent.[67]

Whatever may have been the merits of this approach there are clearly a number of factors that make its implementation difficult. Perhaps the largest obstacles are in the demands placed upon the teacher. The problem of classroom management becomes a problem since it is more difficult to maintain discipline and to keep many children busily engaged in productive work. Furthermore, materials must be assembled and prepared for the lesson and they must be collected and stored following the lesson. The demands for help from floundering students places great demands on the teacher during the instructional period.

There are probably other more subtle reasons why the inquiry approach to instruction is difficult from the teacher's perspective. For one thing, it puts the teacher in a more open-ended and uncontrolled situation and students are likely to raise questions which are very difficult to respond to effectively. For the minimally prepared teacher, especially, such situations are likely to pose real threats to their own self-image and sense of adequacy. Perhaps even more significantly, there is a standard expectation from students, parents, and the community at large that teachers "will know the answers." The teacher-as-authority is deeply ingrained in American folklore and any thing or process that appears to threaten this stereotype is likely to be challenged. The promotion of self-directing skills and a skeptical approach to knowledge is also contrary to the historic submission-authority stance of the schools with respect to students.

From the students perspective, even a conscientious one, there are also problems. Students have been rather thoroughly conditioned to a deductive approach to learning. Any kind of inductive learning, of which inquiry teaching is clearly an example, is likely to be seen as an unaccustomed mode of learning and one that is not particularly appreciated. Most students are "looking for answers" and usually are not caught up in the niceties of the processes involved in obtaining or testing the validity of knowledge. They are likely to view inquiry procedures as "beating about the bush." Admittedly, some teachers can make inquiry techniques work and can change student perspectives. But such a teacher is indeed a *rara avis*.

From still another perspective, the use of inquiry methods is artificial and open to challenge. It may be unreasonable to expect students to sort out data and manipulate materials in ways that enable them to reach conclusions or make observations that were originally discovered and explained by mature individuals with the best minds. Inquiry methods also raise the question of the efficiency of instruction since they are time-consuming and certainly any large scale implementation of such a program will severely restrict the amount of coverage that can be expected. Advocates of inquiry techniques will reject this particular view on the ground that skills and insights gained are more important than coverage geared to teaching programs. But this rejection will not impress many teachers who are concerned about the broad implications of local, state, or national assessment programs and their relationship to accountability and the teacher's own evaluation.

Finally, it seems highly probable that the inquiry mode is not an efficient method of learning for a great many children, sometimes even gifted children. Many students seem likely to profit much more from a structured approach even though some exposure to inferential reasoning seems highly desirable.

Whatever may be the reasons, and several possibilities have been suggested in the paragraphs above, it is apparent that inquiry teaching has not been very successful in the classroom in the American schools based on the evidence submitted in the reports reviewed. One bit of documentation provided for this observation is to be found in the Research

Triangle Institute report which indicates that manipulative materials are used less than once a week in more than half of all science, mathematics and social science classes. Even more distressing is the report that 9 percent of science classes never use manipulative materials and another 14 percent do so less than once a month.[68]

It is apparent that not only inquiry but more traditional laboratory work requiring "hands on" activities is not as common as might be desired.

Teaching Resources

It is curious to note that the question of resources for the teaching of sciences was never addressed directly and completely in any of the studies. Bits and pieces of the resource story trickle through each study, however, and the story is not a happy one. Budget and financing problems are identified repeatedly as the most serious ones faced by the schools.[69] Declining enrollments, increasing costs, taxpayer revolts, and the shrinking value of the dollar are all cutting heavily into the financial resources of the education system. Of all the academic areas of the curriculum, natural science education is hardest hit. This is so because of the experiential, manipulative nature of science programs. While the federally funded innovative curricula designed and developed by teams of experienced scientists and educators called for student activity and the extensive use of concrete materials and experiences, local school system budgets were altered slightly, if at all, to accommodate this approach to the learning of the natural, social, and mathematical sciences.

Teachers of the natural sciences in particular have reported inadequate funds to operate laboratory and field programs and have indicated a special need for funds to purchase supplies on a day-to-day basis.[70-72] A high level of frustration is experienced by them in attempting to prepare, maintain, repair, inventory, order, and clean up materials and equipment in addition to lesson planning, teaching and evaluating. These duties must be performed without the assistance of paraprofessional help.[73]

It is the writer's experience that the U.S. is almost alone in the world in this neglect of the necessary support staff for successful science teaching. Teachers and science educators in other parts of the world are appalled when they learn that the American science teacher is expected to manage without a laboratory technician or other paraprofessional help. Such personnel is considered essential in most other countries, including developing nations.

Some Implications

The three studies are provocative and raise serious questions about many aspects of both education in the sciences and education in general in the public schools of this nation. The nature of the studies was such that many equally important problems were either not touched at all in the studies or were alluded to only in passing. The studies are rich ground which should be plowed in the future for implications of missing questions as well as for those that are included.

National and Local Perceptions of the Educational System

The studies reflect a difference between the perceptions of the national government and of local governments of how schools ought to operate.[74] Many national vs. local perceptions can be considered as paired opposites. Some suggested paired-opposite terms which could be used in helping to clarify these perceptional differences might be: "ideal" versus "practical" solutions, "long term" versus "immediate" goals, "dollar effectiveness" versus "educational effectiveness," "academic discipline" versus "student learning" orientation, "individual student rights" versus "needed social controls," and "theoretical principles and solutions" versus "flesh and blood realities." Other paired opposites could be selected to illustrate some of the perceptual differences at the two levels. Such differences are sources of confusion, controversy, disruption, and hostility.

The large-scale intervention of the federal government in education is a relatively new development and the regulations and controls which have accompanied the federal dollars have run headlong into one of the most cherished of national traditions, namely, local control of the schools. Local control has historically been eulogized as a typically American innovation and one which insured that the schools would be kept "close to the people." The recent trend to reverse such a long established educational doctrine could certainly be expected to generate antagonism.

The developers of the NSF-supported curriculum projects in the 1960s failed to give adequate consideration to many of the historic traditions in American education and to the social settings in which public schools must operate. The constraints related to budgets, teachers' time, equipment, bored and unmotivated students, community pressures, and other factors not seen as formidable obstacles to implementing new programs.

There was also a considerable bit of scapegoating at the time and schools of education were frequently identified as the culprits responsible for all that was wrong with American education. There is still some evidence of the continued existence of the view in some agencies and some legislature that colleges of education cannot be trusted. This is evidenced by providing support for inservice training activities of teachers in non-college and non-university related centers, and by other similar actions which tend to bypass teacher training institutions. It is interesting to consider what the long-range qualitative implications of such developments may be. The main point, however, is that the developers of the curriculum projects tended to ignore the existing power structure. It was certainly their intent to bypass colleges of education and, to a lesser extent, state departments of education in their efforts to reform the curricula of the schools. The following excerpt supports this view.

The projects had, in a sense, circumvented schools of education and gone directly to the elementary and secondary schools in their dissemination efforts; as a result, many methods professors had not had a chance to become familiar with the projects and had, in a sense, been made somewhat "obsolescent" by them. Further, the splitting up of the roles of developer and educator, which had formerly been combined in many methods professors who were both textbook writers and methods teachers, increased the uneasiness of the methods professors. Also the projects approach was at odds with a common conception held by methods professors, of the teacher as developer of his/her own curricula: "methods teachers tend to want a kind of social studies that is not easily prepackaged." [75]

Although the committees and boards of directors responsible for developing the new programs were sprinkled with a few practitioners, and even an occasional science educator, policy control remained firmly in the hands of academicians. By now it is clear that the success of the reformers was only moderate. It is also obvious that not all of the shortcomings of public education can be laid at the doorstep of the schools of education. The implication is also evident that any future national effort should make use of the existing power structure and seek cooperative working relationships with all those who may be legitimately involved. Had this been done, many mistakes might have been avoided and millions of dollars of federal money expended far more efficiently. Support for this position is found in the following paragraph.

Policy formulation at the federal level typically has ignored existing practices in the schools except as mirrored in the disquietude of society. Information was collected after-the-fact of policy decision to confirm the actions taken. The amazing, significant conclusion indicated by this study is that progress has been made without systematic information collection about existing practices. Apparently, the societal/political ethos is sensitive enough to the goals, aims, and objectives of education to provide substantial direction. Thus efficiency in promoting change is the real problem to be faced. The implication is that not only must appropriate kinds of information concerning practice in the schools be collected: sound application of this information must be made.[76]

The Problem of Values

The nation has moved away from the historic sociocultural melting-pot concept in which presumably all minority groups would be eventually fully assimilated to the concept of a pluralistic society where cultural differences are not only tolerated but are to be cherished and perpetuated. The emergence of cultural pluralism as a national goal has contributed to the present anarchy in values. It seems to be tacitly assumed that, of course, values vary from culture to culture. What is frequently overlooked is that there must be large areas of overlap of values held by various minority cultures and the cultural mainstream. Presumably such common values as respect for the individual, personal integrity, and responsibility and concern for others are characteristic of many cultures. What these common areas are need to be identified. The differences, to the extent that they are socially disruptive, should also be analyzed and understood and their implications for education made clear.

A case is continuously made for tolerance and toleration of other people's values and actions, but even tolerance should have its limits. As a society we are certainly under no obligation to tolerate the values of the criminal subculture, for example. There is too much of a disposition to accept the notion that one value is as good as another and that any individual has a right to hold any values he desires. In spite of the prevalence of such a view, neither education nor society in general can tolerate such value anarchy. Some of the reasons for concern about values has recently been summarized as follows:

Values are important because they give direction and consistency to behavior. Man is a social animal and he lives in a social world and, therefore, his behavior *has social consequences. We are fundamentally and ultimately concerned with the values which people hold because of the impact of values on individual and social behavior and social interaction. If this be true then some values have more social utility than others and individual man cannot unilaterally determine for himself what values he will hold. A democratic society cannot long endure value anarchy for values are the social cement which makes productive social intercourse a possibility.*"

One of the results of the emergence of an emphasis on cultural pluralism is teacher uncertainty with respect to their appropriate role in the value orientation of youth. There has been a tendency to shun responsibility in this area.[78] Education has become much more thoroughly secularized, more "amoral," and allegedly "more value free."

Evidence of the impact of pluralism is apparent in the following citations:

> *It is fairly clear why a higher level of constraint on the teacher, as far as the expression of individual values, may emerge in schools with a highly diverse population: the teacher's values conflict with those of at least some of the students.*
>
> *One result of heterogeneity was that teachers felt less influential in the guidance of children. As pressures constraining the teaching of values directly were reduced* [sic: increased?], *the teacher's perception of his/her function seemed to diminish toward one of relaying facts. At any rate, we often found that physics and chemistry were perceived as cut-and-tried collections of facts that could be adequately treated by simply relating them, without emotional connotations, without enthusiasm, without excitement, without creative insight.*[79]

To the extent that teachers perceived the teaching of values as their responsibility, they tended to restrict their teaching to "safe" areas such as "study hard," "be a good subordinate," "work carefully," and "be productive." The Case Study reports tended to subsume the inculcating of such values under the general rubric of "pupil socialization." Although these are surely important, they ignore more important overarching values. It is not only what students know and can do; it is also what they **are disposed to do** with such knowledge and skills and how these learnings can be related to the larger individual and social good.

The question of values is a concern for all of education—not just science education. The question of values was implicit in many places in the case studies but explicit in only a few. The question of values in education is worthy of further study.

Some Action Imperatives

The **contribution of science to the total general education** of students needs immediate attention. This is important for **all** students. It is especially critical for those who will graduate from college and who will eventually assume leadership positions in business, industry, and government but who will not pursue study in scientific fields. One of the constant complaints of members of the scientific community is that key executive and legislative leaders do not understand their needs or the need for a continuing commitment to basic research. Whether better general education in science, which would explicate more fully the nature of science and its contributions to mankind, would accomplish the needed orientation for leaders in key positions who are not scientifically oriented as well as meet the needs of noncollege-trained citizens is perhaps uncertain. Nevertheless, the general education problem seems unsatisfactorily solved at the present time. If citizens are ever to fully appreciate and understand the technological society and its problems, a minimum background in the sciences is essential.

The "**back-to-basics**" **movement** is an established reality. What concerns many informed people is the narrow construction placed on the concept of "basic." The argument for science as "basic" as well as a component of general education should seem irrefutable in the contemporary world.[80]

Counseling of students appears to be either inadequate or ineffective or both. Sound counseling should help to establish long-range personal goals, provide adequate career orientation, ensure appropriate selection of courses and programs and help students to establish wholesome relationships with teachers and the schools. Counseling girls and minorities not to take science and mathematics courses is particularly deplorable. Effective counseling should help to solve disciplinary, motivational, and academic problems. It does not appear to have been notably successful in these areas.

The problem of **student motivation** is critical. The educational and social conditions which contribute to student apathy need to be identified and corrective measures taken. Efforts should be taken to determine if there is a physical basis for some of the problems:

fatigue, inadequate diets, inadequate sleep, drugs, or other physical factors.

Discipline is an increasingly serious problem. Efforts need to be taken to reestablish the authority of the school and its agents. School personnel should be protected from frivolous legal actions. Harassment and intimidation of teachers by students, parents, and overly zealous bureaucrats must be stopped.

There needs to be a **reaffirmation of a concern for quality** in education. The egalitarian philosophy reflected in many educational practices has had the unfortunate effect of encouraging regression toward mediocrity in many parts of the school curriculum. Efforts to reverse this regressive trend are starting. They should be encouraged and supported.

Professional education of teachers needs to be reexamined and high quality standards set for both undergraduate education and for accreditation and certification. Graduate study in any field requires reasonable blocks of time and periods of more or less continuous application. It requires excellent library resources and extensive use of such materials. Interactions over an extended period with peers deeply immersed in common problems has long been recognized as an exceedingly important aspect of graduate study. Appropriate courses in major supporting disciplines should be included.

The kind of education many people believe to be important is difficult to implement under present conditions in most schools. This includes **laboratory activities** on a systematic planned basis, other **manipulative activities, lecture demonstrations, field work,** and **discovery, inquiry, or other inferential teaching** modes. In the past science teachers did more of these things because they had more time and frequently did a considerable portion of their preparation after school hours and on Saturday mornings. New constraints now operate including union rules, busing schedules, more administrative duties, larger school districts with greater commuting time and distance for many teachers, and other factors.

A reasonable solution to the lack of teacher time is to provide paraprofessional assistants. Paraprofessionals can perform such duties as setting up and taking down laboratory and demonstration equipment, maintaining storerooms, checking inventories, ordering supplies, preparing reagents, making minor repairs, maintaining equipment, dispensing storeroom supplies to students, and maintaining aquaria, terraria, and animal cages.

Under the National Defense Education Act millions of dollars were spent for laboratory equipment and facilities. Judging from the evidence in the three reports reviewed, a large part of this material is probably unused or inoperable. This is poor use of federal funds and is probably partially a reflection of inadequate technical assistance for teachers.

Efforts to improve the educational enterprise should utilize **a team approach.** The curriculum projects of the 1960s tended to bypass important segments of the profession. All resources available should be tapped in large-scale efforts to improve curricula. When federal efforts in curriculum reform are initiated, most satisfactory results are likely to be obtained when state and local agencies, academicians, professional educators, and practitioners are involved. Total involvement should occur in the formative as well as in the productive and dissemination stages and it should be genuine participation at all levels including the establishment of policy.

Finally, and extremely important, efforts to improve the schools must start with consideration of the **social environment.** Unless the realities of the many pressures on the school administrators, teachers, and students are understood, efforts to reform the curriculum or any other aspects of the educational establishment are likely to be abortive.

The ten action imperatives identified above are likely to remain empty statements unless solutions can be devised which will move from mere problem recognition to action programs. The three studies document convincingly that there are serious problems in American elementary and secondary education. Science, broadly defined to include the natural sciences, mathematics, and social studies, encompasses a major portion of the total secondary school curriculum and is heavily represented in the elementary school curriculum. It is also apparent that many of the implications for science, so defined, overlap into all of education. Thus, it may be impractical to try to extract science, broadly defined, from the larger matrix and treat it separately. In many cases, it is unrealistic to use the broad definition of science. The laboratory materials and maintenance problems are certainly of a different order in the natural sciences than in either mathematics or social sciences. There are certainly many other differences.

These complexities add greatly to the difficulty in identifying meaningful courses of action. The panel senses that we are at a critical turning point in American education. The confluence of important social, economic, and educational movements seems evident. The era of the great curriculum projects is passing into history and the goals and purposes of education seem once again to be called into question. It is within the context of these observations that the following recommendations are made.

Recommendations

Recommendation 1

Members of the panel agree that a commission of the highest quality with nationally recognized and respected leadership should be established to reexamine in depth the goals and purposes of American elementary and secondary education, and to issue a major new statement to establish a framework for education, and to provide a rationale and justification for new directions. It is the conviction of the panel that education in the sciences should be a major component of all three areas—general, college preparatory, and vocational—and that national attention needs to be directed to the serious problems in science as well as all of education.

The "Committee of Ten" [81] was able to redirect education through its efforts over 85 years ago and major statements on general education emanated from Harvard[82] and the Educational Policies Commission of the NEA[83-85] in various publications of over 30 years ago. But attention to general education and to the broad aims and purposes of education has tended to be subdued in recent decades. Study and a definitive statement of the relationship among general, college preparatory, and vocational educational goals are urgently needed. The social and political context for education and the needs of the citizenry are now so substantially changed that former statements are no longer suitable to the new circumstances.

The proposed commission should be free of bureaucratic and institutional constraints and provided with support staff and time to conduct their study. It would be desirable for the commission to be created by presidential appointment and preferably funded from nongovernmental agencies.

Recommendation 2

The panel recognizes that there are many more limited problem areas unsuited to detailed exploration and attention by a commission charged with broad and sweeping responsibilities for examining the educational establishment of the nation. Some areas will require persistent research efforts over time by highly qualified specialists or teams of specialists. The panel suggests the following as examples of areas which it perceives to be in need of major research efforts:

> "**The student**" is seen as a rich source for investigation. The portrait of many students which emerges from the studies is not a very flattering one. Such terms as bored, apathetic, lazy, unmotivated, and uninterested are applied frequently to students. Research on motivation; counseling effectiveness; learning; impact of social factors including peer pressures, home life, community distractions, and school activities; and attitude formation and change seems badly needed and its results need to be applied. Little is known about the impact of the curriculum on the individual student. This is an area where study is urgently needed. Continued support for such efforts is recommended.
>
> Efforts are needed to protect students against the **misassignment of teachers.** This is a serious problem and one which is likely to grow worse because of the prevalence of reductions in staff in many school systems. At the very least, the general public, the state departments of education, and various accrediting and regulating bodies should be urged to give their attention to the problem and to do all they can to mitigate its effect. More reliable data on the extent of the problem is needed.
>
> **Inservice education** of teachers continues to be a problem area. While there is general agreement that teacher renewal and updating is a necessity, the manner in which it is to be accomplished is far from settled. Mechanisms need to be devised to monitor the quality of inservice education. Graduate schools and accrediting agencies need to reaffirm their concerns for quality. Research is needed on all aspects of teacher inservice education programs but especially on the aspects relating to quality.
>
> It is recommended that support be sought for programs and studies to determine what the contribution of **paraprofessionals** might be with special reference to increased teaching effectiveness and increased student learnings as indicated by their performance.
>
> Extensive investigation of the function and role of **values** in the education of youth is recommended. This is an issue that should also be a concern of the commission (Recommendation 1).

PANEL TO REVIEW THREE NSF STUDIES

Kay Davis
Fernbank Science Center
156 Heaton Park Drive, N.E.
Atlanta, Georgia 30307

Marjorie Gardner
Department of Chemistry
University of Maryland
College Park, Maryland 20742

Dorothy Goodman
International School
2735 Olive Street, N.W.
Washington, D.C. 20007

Frederick Mosteller
Department of Statistics
Harvard University
Cambridge, Massachusetts 02138

David Ost
Department of Biology
California State College
Bakersfield, California 93309

Constance Tate
Baltimore City Public Schools
Office of Science—DICM
1401 E. Olive Street
Baltimore, Maryland 21213

Herbert Smith
Assistant to the Vice President for Academic Affairs
Colorado State University
Fort Collins, Colorado 80523

AAAS REPRESENTATIVES

Office of Science Education:
Arthur Livermore, Director of the Project
Joseph Dasbach

Office of Opportunities in Science:
Michele Aldrich
Cheryl Davis

References

[1] Kay Davis, Fernbank Science Center, Atlanta; Marjorie Gardner, Department of Chemistry, University of Maryland; Dorothy Goodman, International School, Washington, D.C.; Frederick Mosteller, Department of Statistics, Harvard University; David Ost, Department of Biology, California State College, Bakersfield; Constance Tate, Office of Science—DICM, Baltimore City Public Schools; and Herbert A. Smith, Assistant to the Vice President for Academic Affairs, Colorado State University.

[2] *Case Studies in Science Education: The Case Reports.* Center for Instructional Research and Curriculum Evaluation and Committee on Culture and Cognition. University of Illinois at Urbana-Champaign, Volume I, January 1978.

[3] *Case Studies in Science Education: Design, Overview and General Findings.* Center for Instructional Research and Curriculum Evaluation and Committee on Culture and Cognition. University of Illinois at Urbana-Champaign, Volume II, January 1978.

[4] *The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies.* National Science Foundation Directorate for Science Education, U.S. Government Printing Office, July 1978.

[5] Stanley L. Helgeson, Patricia E. Blosser, and Robert W. Howe. *The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Volume I: Science Education.* Center for Science and Mathematics Education, The Ohio State University, Columbus, Ohio, 1977.

[6] Marilyn N. Suydam and Alan Osborne. *The Status of Pre-College Science, Mathematics and Social Science Education: 1955-1975. Volume II: Mathematics Education.* Center for Science and Mathematics Education, The Ohio State University, Columbus, Ohio, 1977.

[7] Iris R. Weiss. *Report of the 1977 National Survey of Science, Mathematics and Social Studies Education.* Center for Educational Research and Evaluation, Research Triangle Institute, Research Triangle Park, North Carolina, 1978.

[8] Karen B. Wiley and Jeanne Race. *The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Volume III: Social Science Education.* Social Science Education Consortium, Inc., Boulder, Colorado, 1977.

[9] Helgeson, *et al, op. cit.*, p. 16.

[10] Wiley and Race, *op. cit.*, pp. 154-58.

[11] *Case Studies in Science Education*, Volume I, *op. cit.*, Chapter 4, p. 43.

[12] *Case Studies in Science Education*, Volume I, *op. cit.*, Chapter 1, p. 59.

[13] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 16, p. 26.7.

[14] *Case Studies in Science Education*, Volume I, *op. cit.*, Chapter 5, p. 9.

[15] *Case Studies in Science Education*, Volume I, *op. cit.*, Chapter 9, p. 1.

[16] *Ibid.*, p. 17.

[17] *Ibid.*, Chapter 11, p. 4.

[18] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 16, p. 16:26.2

[19] *Case Studies in Science Education*, Volume I, *op. cit.*, Chapter 1, p. 89.

[20] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 12, p. 18; 25a.

[21] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 17, p. 25.

[22] *Ibid.*, Chapter 12, p. 23.

[23] *Case Studies in Science Education*, Volume I, *op. cit.*, Chapter 11, p. 27.

[24] Jerome S. Bruner, *The Process of Education*, Cambridge, Mass., Harvard University Press, 1961, p. 33.

[25] *Case Studies in Science Education*, Volume I, *op. cit.*, Chapter 4, pp. 24-25.

[26] *Case Studies in Science Education*, Volume I, *op. cit.*, Chapter 1, p. 40.

[27] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 13, p. 44.

[28] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 14, pp. 12-13.

[29] B. F. Skinner, "The Free and Happy Student," *Phi Delta Kappan*, September 1973, p. 14.

[30] *Ibid.*, p. 16.

[31] *Case Studies in Science Education*, Volume I, *op. cit.*, Chapter 11, p. 38.

[32] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 16, p. 26.7.

[33] *Case Studies in Science Education*, Volume I, *op. cit.*, Chapter 9, p. 5.

[34] *The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies, op. cit.*, Chapter 19, p. 1.

[35] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 16, p. 2.

[36] *Ibid.*, p. 26.5.

[37] Weiss, *op. cit.*, p. 46.

[38] Weiss, *op. cit.*, p. 143.

[39] Suydam and Osborne, *op. cit.*, p. 130.

[40] Suydam and Osborne, *op. cit.*, p. 166.

[41] Weiss, *op. cit.*, p. 142.

[42] American Association for the Advancement of Science, *Preservice Science Education of Elementary School Teachers*, 1970, and *Guidelines and Standards for the Education of Secondary School Teachers of Science and Mathematics*, 1971.

[43] Helgeson *et al*, *op. cit.*, p. 69.

[44] Wiley and Race, *op. cit.*, p. 58.

[45] *Ibid.*, p. 161.

[46] Suydam and Osborne, *op. cit.*, p. 144.

[47] *Ibid.*

[48] Helgeson *et al*, *op. cit.*, p. 70.

[49] The reference is to the NSF-supported summer and inservice institutes for precollege teachers that were a major effort of NSF in the 1960s.

[50] Suydam and Osborne, *op. cit.*, p. 167.

[51] *Ibid.*, p. 136.

[52] *Ibid.*, p. 59.

[53] *Ibid.*, p. 58.

[54] *The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies*, *op. cit.*, Chapter 19, p. 3.

[55] *Ibid.*, pp. 2-3.

[56] *Case Studies in Science Education*, Volume I, *op. cit.*, Chapter 1, p. 40.

[57] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 12, p. 7.

[58] *Ibid.*, Chapter 16, p. 16.

[59] Helgeson *et al*, *op. cit.*, p. 37.

[60] Herbert Spencer, "What Knowledge Is of Most Worth?" *Education*, E. L. Kellogg & Co., New York, 1892, pp. 5-69.

[61] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 12, p. 1.

[62] Weiss, *op. cit.*, p. 59.

[63] *The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies*, *op. cit.*, Chapter 19, p. 7.

[64] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 13, p. 66.

[65] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 13, p. 9.

[66] *Ibid.*

[67] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 12, p. 7.

[68] Weiss, *op. cit.*, p. 107.

[69] Helgeson *et al*, *op. cit.*, p. 133.

[70] Weiss, *op. cit.*, p. 126.

[71] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 13, p. 4.

[72] Weiss, *op. cit.*, p. 135.

[73] *Ibid.*

[74] *Case Studies in Science Education*, Volume, II, *op. cit.*, Chapter 17, pp. 1-2.

[75] Wiley and Race, *op. cit.*, pp. 138-39.

[76] *The Status of Pre-College Science, Mathematics, and Social Studies Education Practices in U.S. Schools: An Overview and Summaries of Three Studies*, *op. cit.*, p. 30.

[77] Herbert A. Smith, *Science Education: Past or Prologue*, 1978 AETS Yearbook, Association for the Education of Teachers of Science, ERIC Information Analysis Center, Columbus, Ohio, p. 226.

[78] *The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies*, *op. cit.*, Chapter 19, p. 4.

[79] *Case Studies in Science Education*, Volume II, *op. cit.*, Chapter 12, p. 32.

[80] Howard J. Hausman, *Choosing a Science Program for the Elementary School*, Council for Basic Education, Washington, D.C., 1976.

[81] National Education Association, *Report of the Committee on Secondary School Studies*, Committee on Secondary School Studies, U.S. Bureau of Education Bulletin No. 205, GPO, Washington, D.C., 1893.

[82] Harvard University, *General Education in a Free Society*, Committee on the Objectives of General Education in a Free Society, Harvard University, 1945.

[83] National Education Association, *Education for All American Youth, A Further Look*, Educational Policies Commission, National Education Association, 1952.

[84] National Education Association, *The Purposes of Education in American Democracy*, Educational Policies Commission, National Education Association, 1938.

[85] National Education Association, *The Unique Function of Education in American Democracy*, Educational Policies Commission, National Education Association, 1937.

National Academy of Sciences,
National Research Council

The State of School Science. A Review of the Teaching of Mathematics, Science, and Social Studies in American Schools, and Recommendations for Improvements

Panel on School Science
Commission on Human Resources

Summary

During the 1950s and 1960s a national effort to improve precollege education resulted in the development of new courses and teaching materials for instruction in elementary and secondary school mathematics, science, and social studies, and resulted also in the offering of a large number of institutes to increase the knowledge of school teachers and to help them learn to use the new courses and materials effectively.

The 1970s brought a great reduction in the number of institutes for teachers and a substantial decline in usage of the new courses and materials. The National Science Foundation, which has played a leading role in the whole effort toward improvement, sought to determine the current status of teaching and learning in elementary and secondary schools, and to reassess its own responsibility for precollege education. To that end, NSF commissioned three national studies of the status of precollege education, and then asked eight national organizations to review those three studies and to state current needs as they saw them. This paper is one of the eight responses to that request.

Survey data, firsthand observation, and other evidence from the three studies commissioned by NSF described a troubled American school system. Declining enrollments, financial stringency, the unsatisfactory performance of many pupils and graduates, pressure for greater accountability, disagreements over educational policy—these and other forces have affected the teaching of science and mathematics as they have nearly every aspect of the nation's schools.

Nevertheless, there are good students, eager to learn. Good teaching is to be found. Many teachers wish to improve their knowledge and skills and to have better texts and teaching materials. The first three sections of this paper describe the conditions under which these teachers work, the variability, the trends, and the problems as reported in the three NSF studies and as indicated by other reports and evidence.

Drawing upon the findings of the three NSF studies and other information, the Panel on School Science of the National Research Council's Commission on Human Resources considered the current needs for improving education in science and mathematics and offers the following recommendations:

1. We recommend the establishment of a number of Science and Mathematics Teaching Resource Centers, each to serve a large school system or a group of neighboring smaller systems. Each Teaching Resource Center would offer some or all of the following services:

   Inservice training programs related to the science and mathematics courses being taught or to be introduced in the school systems involved.

   Construction, maintenance, repair, and distribution of kits of materials required to teach those courses.

   Expert advice to teachers to help them learn to use new science and mathematics instructional materials and techniques, and to help them with their individual teaching problems.

2. We recommend increased support for the NSF program of funding the design, experimental testing, and revision of new courses in science and mathematics and their associated teaching and learning materials.

3. We recommend support of an NSF program of institutes for teachers, both to increase their knowl-

---

This was published as a report of the Commission on Human Resources of the National Research Council.

edge of subject matter and to improve their skill in teaching the new courses that will be developed in the future, whether the development of those courses is funded by public or by private sources.

4. We recommend the development of additional science and technology centers of the kind that now exist in a number of cities. Furthermore, we recommend the strengthening of cooperative arrangements between these centers and nearby school systems to increase the extent to which the centers provide planned supplementation of the programs of the associated schools, and to increase their general value to children and adults who wish to learn more about science.

5. In order to give women and members of racial or ethnic minority groups greater opportunity to become interested in and to prepare for careers in scientific and technical occupations, we recommend that scientists and engineers work with their local school systems to provide special lectures and classes; tours of local scientific, engineering, and technical facilities; opportunities to meet with appropriate role models; and other experiences intended to increase their motivation and to overcome their disadvantages in securing the education necessary for scientific and technical careers. In addition, we recommend that efforts be made to identify gifted but economically disadvantaged students early in their schooling, so as to ensure that they will be afforded adequate opportunities to prepare themselves for admission to scientific and technological programs in college.

6. We recommend vigorous efforts at local levels to combat the overemphasis currently given to scores on standardized tests of achievement in comparing the performance of schools, classes, and individual pupils. Because the tests most generally used for these purposes give emphasis to the more elementary and routine abilities necessary to meet "minimum competency" requirements, they constitute only a part of the basis upon which schools and pupils should be judged. In addition, in order to make available more desirable tests with which teachers can appraise the performance of their pupils, we recommend the creation, for each major subject, of a large bank of test items, of varied types, and covering a wide range of skills and knowledge of the field. These test banks should be openly available to any teacher, school administrator, parent, child, or anyone else who is interested. Open availability of the entire bank of test items should improve the quality of test items and will give teachers latitude in selecting the test questions that match their educational objectives.

Finally, we recommend that scientists take the lead in evaluating these and other recommendations for the improvement of science education at the precollege level, and in developing the specific programs and activities necessary to implement the recommendations that seem most promising. Scientists will have to accept responsibility for leading the whole effort, for it is not likely that anyone else will.

Introduction

Beginning in the 1950s, several groups of scientists and mathematicians set out to achieve major improvements in the teaching of science and mathematics in the nation's schools. Congress responded quickly and generously by providing financial support for the National Science Foundation's Course Content Improvement Program, and for hundreds of institutes to enhance the knowledge and teaching effectiveness of thousands of teachers.

These cooperative efforts produced a rich variety of carefully prepared and well proven materials for teaching science[1] at all ages from kindergarten through grade 12. All over the country some teachers, particularly at the high school level, are making good use of at least parts of these materials and some of the innovations have been imitated in texts prepared under more traditional arrangements. Some teachers are helping their students learn how to ask questions and search for answers instead of simply relying on what the textbook says. And many teachers are better trained than they would have been without the benefit of attendance at a National Science Foundation institute for teachers. In short, the teaching of science in grades K-12 is on a higher plane than it was when the Course Content Improvement Program started.

Yet there has also been considerable slippage. Many of the innovative teaching programs are being used less widely than they were. Some of their ideas and techniques have been watered down as they have been transplanted into new settings and adapted by new authors.

Science is not alone in having difficulties; the whole educational system is in trouble. The inability of many students to read and write as well as expected is a frequent complaint at all school levels from the middle grades to college. Criticisms of the schools and of some educational innovations have induced a defensive reaction that encourages a "back to the basics" emphasis on the three R's and allots correspondingly less attention to science. Tax revolt, flight of some students to the suburbs or to private schools, and declining enrollments have restricted the funds that might have been used to overcome some of these difficulties.

---

[1] Unless the context or wording indicates a narrower meaning, **science** is used in this chapter, as it is in many reports of the National Science Foundation, to include mathematics, the natural sciences, and the social sciences.

Aware of these troubles and aware also of the declining usage of the innovative teaching programs that had been developed under its auspices, the National Science Foundation commissioned three studies of the status of teaching of mathematics and the natural and social sciences in American schools. The Research Triangle Institute of North Carolina conducted a national survey of school administrators and teachers. The Ohio State University, with help from the Social Science Education Consortium of Boulder, Colorado, searched and summarized the literature on the teaching of mathematics, the natural sciences, and the social sciences. The University of Illinois carried out case studies of 11 selected and widely distributed high schools and the lower schools from which each drew its students. All three of these studies were expected to result in status reports; their authors were not invited to make suggestions for improvement or change.

Following receipt of these three studies, the National Science Foundation invited the National Academy of Sciences "to submit a proposal outlining an approach to summarizing relevant findings (of the three studies) and developing needs statements from the point of view of the membership." Simultaneously, similar requests were addressed to seven other organizations that were expected to view the status of the teaching of science and mathematics from the points of view of their constituencies.

Judged on the basis of the Panel members' other knowledge about American schools, these reports provide a clear and representative picture of the current status of precollege education in science and mathematics.

The statistical survey conducted by the Research Triangle Institute yielded useful information from a representative sample of teachers, principals, and curriculum supervisors. The Panel found the information regarding course offerings, enrollments, and current usage of federally funded curriculum materials to be the most valuable. It is unfortunate, however, that this survey did not provide statistical information that was more relevant to some of the serious questions raised by the NSF case studies.

The literature reviews seemed to be an adequate and fair review of much of the existing literature concerning educational practices and needs in science, mathematics, and social studies. For the Panel's purposes, however, these literature reviews were less useful than the other two studies.

The NSF case studies, like all such studies, concentrated on an in-depth analysis of some particular school settings. There is no way of telling how representative the selected eleven school districts, but the case study approach did allow the investigators to present detailed descriptions of a series of specific problems that are certainly not uncommon in many other American schools.

The three studies will be referred to so often in this chapter that they need a standard form of reference. When all three are meant, they will be called "the three NSF studies." The national survey conducted by the Research Triangle Institute will be called "the NSF statistical survey" and will be cited as (Weiss, 1978). The literature search was in three volumes. When referred to separately, they will be identified and cited as follows: "the science education literature review" (Helgeson, Blosser, and Howe, 1977); "The mathematics education literature review" (Suydam and Osborne, 1977); and "the social science education literature review" (Wiley and Race, 1977). When all three volumes are meant, the collective reference will be to the "NSF literature review." The case studies and their analyses will be referred to as "the NSF case studies" and will be cited as (Stake and Easley, 1978).

Responsibility for reviewing these three studies and preparing this report was assigned to the National Research Council's Commission on Human Resources, which appointed an ad hoc Panel on School Science for the purpose. Members of the panel were:

Leallyn B. Clapp, Department of Chemistry, Brown University

Johns W. Hopkins, III, Department of Biology, Washington University.

*Grace M. Hopper, Captain, United States Navy

*Gordon Millar, Vice President Engineering, Deere and Co.

John A. Moore, Department of Biology, University of California, Riverside

David Page, Departments of Education and Mathematics, University of Illinois, Chicago Circle, Chicago

James Perkins, Department of Chemistry, Jackson State University, Jackson, Mississippi

---

*Captain Hopper and Dr. Millar did not attend either meeting of the Panel. Dr. Colin Hudson of Deere and Company attended both meetings as an observer and made valuable suggestions.

best copy available

Gerard Piel, Publisher, *Scientific American*

Sylvia D. Roberts, The Spence School, New York City

David Z. Robinson, Carnegie Corporation of New York

John G. Truxal, College of Engineering and Applied Science, State University of New York at Stony Brook

Dael Wolfle (Chairman), Graduate School of Public Affairs, University of Washington

Jerrold R. Zacharias, Education Development Center, Newton, Massachusetts

Douglas Lapp, Science Specialist for the Fairfax County (Virginia) School System, served as consultant to the Panel.

The first three sections following this introduction were written by Dr. Douglas Lapp. They review the three NSF studies and on a number of points compare the findings of those studies with information from other sources. These sections analyze the data and observations provided by the three NSF studies to answer the following questions: (1) What emphasis do science, mathematics, and social studies receive in the curriculum of the elementary schools? (2) What constitutes the curriculum in science, mathematics, and social studies in the nation's secondary schools? (3) What factors currently appear to be adversely affecting the quality of precollege instruction in science, mathematics, and social studies?

The remainder of the report is the work of the Panel members. Its recommendations are based upon the findings of the three studies, other reports reviewed by the Panel, and the collective experience of the Panel members.

The Elementary School Curriculum

Allocation of Instructional Time

The NSF statistical survey indicates that 25 percent of the states and 40 percent of the school districts in the nation set guidelines for the minimum amount of time to be spent on each subject in the elementary grades. In districts that have such guidelines, for grades one through three, the average recommended minimum times are 30 minutes per day each for science and social studies. In grades four through six a minimum of 30 to 40 minutes of daily instruction is recommended for each of these subjects (Weiss, 1978, p. 22).

The elementary teachers surveyed indicated that they "typically" spent about 20 minutes each day on science and 20 minutes on social studies in grades K-3, as compared to 40 minutes on mathematics and 95 minutes on reading. In grades 4-6, upper elementary level teachers estimated that they usually spent about 30 minutes each day on science, 35 minutes on social studies, 50 minutes on mathematics, and 65 minutes on reading (Weiss, 1978, p. 51).

The above figures for elementary science do not differ radically from previous estimates; summarizing data from several independent surveys, Helgeson *et al.* concluded that about 60 minutes per week were devoted to science in grade 1, increasing to 110 to 140 minutes per week in the upper grades (1977, p. 32). For mathematics, the surveys summarized by Suydam and Osborne (1977, pp. 52-53) indicated that approximately 20 percent of the six-hour elementary school day has generally been allocated to mathematics instruction, a considerably larger amount of time than that reported by Weiss.

In the NSF case studies, Stake and Easley indicate that the teaching of science had a very low priority in most of the elementary schools visited.

> *Most schools we studied had some written policy about what and how elementary science should be taught, but what actually was taught was left largely to individual teachers. By and large, the elementary teachers did not feel confident about their knowledge of science, especially about their understanding of science concepts. Even those few who did like science and felt confident in their understanding of at least certain aspects of it often felt that they did not have the time nor material resources to develop what they thought would be a meaningful program. As a consequence, science had been deemphasized at the elementary school level, with some teachers ignoring it completely.*
>
> *When and where science was formally taught, the instructional material was usually taken directly from a textbook series. The method of presentation was: assign—recite—test—discuss. The extent to which the emphasis on reading and textbooks pervaded the elementary science program is illustrated by an episode observed in an elementary life science class where the teacher opened a recitation period with the question: How do we learn? A chorus of students replied: "We learn by reading. . ."*

> *Other than the fairly common practice of learning science by reading from a textbook series, the selection of what was to be read and the actual time spent on reading science varied greatly from teacher to teacher. In most of our school systems, no district-wide elementary science program was identified (Stake and Easley, 1978, pp. 13:5-13:6).*

Social studies instruction also took a back seat to instruction in the "basic skills" of reading and computation in the elementary schools studied:

> *As a content area, social studies was found to be subordinate to reading and mathematics in the elementary curriculum. At each of the sites there was some kind of social studies curriculum, but teachers and principals readily admitted that instruction in this area was of much lower priority than reading or math. It had about the same priority as instruction in science. Social studies lessons were seen to be given more time than science by most K-6 teachers, perhaps because they were more knowledgeable about social studies than science (Stake and Easley, 1978, p. 13:28).*

Use of Federally-Funded Curriculum Materials in Elementary Schools

Local school district personnel responding to the NSF statistical survey indicated that 31 percent of the districts claimed they were using one or more of the federally-funded elementary science curriculum materials. In social studies, the figure was 25 percent, while only 8 percent of the districts indicated use of any federally funded mathematics materials. These data are compared with usage prior to 1976 in Table 2-1.

Table 2-1. Percent of School Districts Using One or More of the Federally-Funded Elementary School Curriculum Materials in Each Subject

Subject	1976-1977	Prior to 1976-1977
Science	31	26
Mathematics	8	37
Social Studies . . .	25	24

Source: Weiss, 1978, p. 79.

Teachers were also asked to indicate which federally funded curriculum materials they had actually used in the classroom. The most commonly used federally funded curriculum materials in each discipline are shown in Table 2-2, with the corresponding percentages of districts and teachers who indicated use. The reader will note that there is often considerable disagreement between the usage figures reported by school district personnel and the information supplied by teachers. Weiss suggests that the data obtained from teachers are likely to be more accurate, since the respondents for school districts may not have been fully cognizant of the programs actually used in the schools and because not all schools in a given school district use the same programs (1978, p. 82).

Table 2-2. Use of Selected Federally-Funded Curriculum Materials In Elementary Schools

	Percent of School Districts Using Selected Materials		Percent of Teachers Using Selected Materials			
			K-3		4-6	
Curriculum	Using in 1976-1977	Used Prior to 1976-1977	Using in 1976-1977	Used Prior to 1976-1977	Using in 1976-1977	Used Prior to 1976-1977
K-6 Science						
Elementary Science Study (ESS)	15	13	5	7	9	14
Science—A Process Approach (SAPA)	9	10	4	10	9	13
Science Curriculum Improvement Study (SCIS) . .	8	8	11	16	12	16
K-6 Mathematics						
Developing Mathematical Processes (DMP)	1	3	1	3	3	4
ERC Mathematics (Greater Cleveland)	0	8	2	22	1	8
Individualized Mathematics System	4	11	4	7	3	9
Individually Prescribed Instruction	2	3	1	3	2	7
School Mathematics Study Group (SMSG)	0	18	0	4	0	9
K-6 Social Studies						
Concepts and Inquiry (ERC)	2	2	2	4	2	4
Elementary Social Science Education Program Laboratory Units (SRA)	12	3	3	14	6	5
Family Man (Minnesota)	1	2	1	4	1	1
Man: A Course of Study (MACOS)	1	3	0	0	2	5
Materials and Activities for Children (MATCH) . .	—	—	1	1	3	5
Our Working World	8	16	5	15	2	10
Taba Program in Social Science	2	2	1	2	1	3

Source: Weiss, 1978, Appendix B, pp. 22-25, 36-40.

It should also be noted that the usage figures in Table 2-2 cannot be used to calculate meaningful subtotals for science, mathematics, and social studies, since school districts and teachers commonly use materials from more than one federally funded project in a given category. Furthermore, only the most commonly used federally funded curriculum materials are listed in Table 2-2.

Table 2-3 tabulates the percent of teachers who were using at least one of the federally funded curriculum materials during 1976-1977, by subject and grade range.

Table 2-3. Percent of Elementary School Teachers Using One or More of the Federally Funded Curriculum Materials in Each Subject (1976-77)

	Science	Mathematics	Social Studies
K-3	20	8	11
4-6	27	10	12

Source: Weiss, 1978, p. 83.

The 1976-77 usage figures shown in Tables 2-1 2-2, and 2-3 are lowest in mathematics. The use of a federally funded elementary mathematics program was reported by only 8 percent of the school districts and by less than 10 percent of the teachers. However, these figures may be somewhat misleading since the intention of many of the developers was to have their "innovations" incorporated into commerically developed textbooks and this has occurred to a limited extent.

Although the NSF statistical survey identifies the most commonly used mathematics textbooks, no attempt was made to analyze their content. However, the Educational Products Information Exchange (EPIE) Institute did make such an analysis in the National Survey and Assessment of Instructional Materials (NSAIM), which was completed in 1976. This *EPIE Report* (1977a, p. 22) indicated that the ten most-used materials in mathematics (K-12) were clearly traditional programs, quite similar to each other in instructional design. They were also traditional in the way in which they were developed. Of the ten most-used materials, six were marketed by the same publisher. Among the 32 most popular mathematics materials listed in the *EPIE Report*, only one was the result of nontraditional development; this development was federally funded. This mathematics material ranked 24th, and was cited by only 2.4 percent of the EPIE survey's respondents. The EPIE evaluators came to the following conclusions:

> *Of the remaining 31 materials in the first group, at best two could be considered to have even a modicum of an R&D base. This is not to say that R&D-based materials are necessarily the "best" or the "right" materials for every classroom, but it is to say that they are more likely to perform as promised when used as directed with an appropriate student population. By R&D-based materials, we refer to materials built upon an empirical data base, as opposed to conventional wisdom, and developed through continuous feedback loops that insure that once obtained data hold steady over time. A traditionally developed material uses little more than "conventional wisdom," that is, usually the manuscript is written by a publishing company's editor, who often is a former teacher, and it receives as "input" critical readings by those who are listed as authors and suggestions from sales representatives and production staff members (EPIE Institute, 1977a, p. 22).*

In the case of social studies, although the EPIE survey concluded that most of the ten most-used social studies materials were fairly alike, there were some innovative materials in the group (EPIE Institute, 1977a, p. 23). The NSF statistical survey also revealed that some federally funded social studies materials were among those that were most commonly used in the elementary grades (Weiss, 1978, p. B-46).

The NSF statistical survey's estimates of teacher usage of the three NSF-funded elementary science programs are lower than those which have appeared in earlier studies. Using data from state reports through 1975, Helgeson *et al.* (1977, p. 18) estimated that Science Curriculum Improvement Study (SCIS) materials were being used in schools in which 17 percent of the K-6 students in the nation were enrolled; Elementary Science Study (ESS) materials were in use in schools which contained 12 percent of the students; for the Science, A Process Approach (SAPA) program the figure was 20 percent. The discrepancy between these estimates and the NSF statistical survey data is probably due to the phenomenon mentioned earlier, that state and district supervisors often do not know which materials are actually being used in teachers' classrooms. Also, even though a few teachers in a given school may be teaching one of the new elementary science programs, this does not guarantee that all students are receiving such instruction.

During the 1970s several publishers produced "hybrid" elementary science texts which incorporated some of the emphases of the three NSF-funded elementary science programs (Hausman, 1976). The authors of the NSF science education literature review commented on the impact of these materials:

> *It is evident that the content and activities of these (hybrid) materials is different from the textbooks of the 1950's. Curriculum guides and teacher guides produced by states and local school districts since 1972 are closer in emphasis to the NSF projects and recent "hybrid" materials than to the textbooks of the 1950's (Helgeson et al., 1977, p. 18).*

However, the NSF statistical survey's data on textbook usage suggest that the second generation "hybrid" materials have not captured a significant fraction of the elementary science textbook market (Weiss, 1978, p. B-44). The four most commonly used elementary science texts listed in the NSF statistical survey utilize for the most part a didactic approach to science, in which most of the learner's time is spent reading and listening (EPIE Institute, 1977b).

The Curriculum in Secondary Schools

Science, Mathematics, and Social Studies Requirements

Most school systems questioned in the NSF statistical survey have established standards as to the minimum amounts of grade 9-12 instruction in science, mathematics, and social studies required for high school graduation. These requirements are summarized in Table 2-4.

Table 2-4. Percent of School Districts Requiring Minimum Amounts of Grade 9-12 Instruction in Each Subject

	Less Than 1 Year	1 Year	More Than 1 Year	Unknown
Science	2	54	33	11
Mathematics	4	47	33	16
Social Studies	2	5	74	20

Source: Weiss, 1978, p. 25.

In general, graduation requirements are significantly greater in social studies than in science or mathematics; approximately three-fourths of the districts reported that they require more than one year of social studies, compared to one-third of the districts in both science and mathematics. (Note that 20 percent of the districts surveyed did not answer this question for social studies, while 16 percent omitted the answer for mathematics and 11 percent for science, possibly because they have no requirements in the subject.) After reviewing state social studies requirements, Wiley and Race (1977, p. 34) determined that two or three years of social studies are usually required at the senior high school level.

Most districts (86 percent) require one or more specific courses in social studies; the courses most commonly required are United States history, American government, and world history. Less than half of the districts require specific courses in math or science. When specified, such science course requirements typically include general science, biology, or physical science; specific math course requirements are typically general mathematics or elementary algebra (Weiss, 1978, p. 26).

Course Offerings (Grades 7-12)

In the NSF statistical survey, the most commonly taught science, mathematics, and social studies courses in grades 7-9 and 10-12 were ascertained from teacher questionnaire data. The results are shown in Table 2-5.

At the junior high school level (grades 7-9), it will be noted that four courses (general science, earth science, life science, and physical science) account for 86 percent of the science classes. General mathematics and algebra together account for 87 percent of the mathematics classes, and American history and "social studies" account for 52 percent of the social studies classes.

For grades 10-12, biology, chemistry, and physics together account for 74 percent of the science classes; algebra and geometry together represent more than two-thirds of all 10-12 mathematics classes. In the case of social studies, numerous elective courses together account for as many classes as American history and world history, which together account for 37 percent of the 10-12 social studies classes.

Data collected by the NSF statistical survey do not lend themselves to calculations of the percentage of high school students who take a specific course prior to graduation. However, a smaller scale survey, conducted as a part of the NSF case studies, did collect some pertinent data. In this survey, 361 high school seniors were asked to indicate the science, mathematics, and social studies courses they had taken **prior to their senior year** in grades 9, 10, and 11. The results are tabulated in Table 2-6.

Table 2-5. Most Commonly Offered Science, Mathematics, and Social Studies Courses

Grades 7-9		Grades 10-12	
Course	% of Classes	Course	% of Classes
Science			
General Science	30	Biology	40
Earth Science	25	Chemistry	19
Life Science	16	Physics	15
Physical Science	15	Advanced Biology (2nd year)	5
Biology	6	Other Courses	21
Other Courses	8		
Mathematics			
General Mathematics	64	Algebra	38
Algebra	23	Geometry	30
Remedial Mathematics	4	Advanced Mathematics and Calculus	7
Other Courses	9	Consumer/Business Mathematics	6
		General Mathematics	5
		Other Courses	14
Social Studies			
American History	34	American History	27
Social Studies	18	World History	10
State History	7	Psychology	7
Civics	6	American Culture/ Contemporary Issues	7
World Geography	6	United States Government	6
Other Courses	29	Economics	5
		Other Courses	38

Source: Weiss, 1978, pp. 63-64.

Table 2-6. Percentage* of Grade 12 Students Who Had Completed Specific Courses in Grades 9-11

Course	% of Seniors	Course	% of Seniors
General Science	62	Advanced Algebra	38
Biology	87	Calculus	2
Chemistry	46	American History	94
Ecology	10	American Government	33
Basic Math	46	Psychology	14
Algebra	88	Sociology	12
Geometry	74	Economics	23

*Unweighted percentages

Source: Stake and Easley, 1978, p. 18:26.

It is curious that earth science was not included in the questionnaire given students; the topic of earth science courses seemed to have been generally neglected in the NSF case studies, even though earth science courses represent 25 percent of the science classes taught in grades 7-9 (Weiss, 1978, p. 63).

Physics is not included in Table 2-6 because it is usually taken in grade 12, making the survey results for this subject not very useful. For the same reason, it is likely that the percentages listed in Table 2-6 for most upper-level courses (including chemistry and calculus) would be higher if a survey had been taken at the end of the senior year so that good estimates could have been made for all courses taken through grade 12. It is unfortunate that neither this NSF case studies survey nor the larger NSF statistical survey provided such estimates.

Taken at face value, the data in Table 2-6 indicate that approximately 90 percent of high school students take biology, algebra, and American history in grades 9-11; three-fourths of the students take geometry, about two-thirds take general science, and approximately one-half take chemistry. These percentages are all somewhat reliable. They are not in good agreement with what one would intimate from Table 2-7, and the students polled were not a nationally representative sample. Nevertheless, unless course enrollment patterns change radically, it would appear that these six courses represent the most appropriate targets for future high school curriculum development efforts aimed at improving general public literacy in science, mathematics and social studies.

Course Enrollment Trends

Science. The NSF case studies and the associated survey of science curriculum supervisors both suggested that a decline in science enrollments might be occurring in secondary schools. In particular, the NSF case studies observers noted declining enrollments in chemistry and physics. Reasons given by school system personnel for this apparent decline included reduced graduation requirements, more competition from other elective courses, the fact that these subjects could be picked up in junior college, if needed, and the perception of high school students that the content of physics and chemistry is not "relevant" (Stake and Easley, 1978, p. 13:4).

The Condition of Education, 1978 reports that in 1976 the size of the 14- to 17-year-old population in the nation began to decrease (National Center for Educational Statistics, 1978, p. 5), following a large increase in the size of this age group during the previous two decades. The peak in the growth of the student population in grades 7, 8, 9 occurred in 1972-73. The authors of the NSF science education literature review assert that the subsequent decline in total enrollment has affected the number of junior high school students taking science, but that the **percentage** has remained about constant since 1973 (Helgeson *et al.*, 1977, p. 24).

Summarizing both national statistics and state data, the same authors note that general science was the science course most commonly taken by students in grades 7, 8, and 9 in the 1950s. Since then, there has been a decline in general science enrollments as that course has been increasingly replaced by life science, physical science, and earth science in grades 7, 8, and 9. There has been an especially sharp rise in earth science enrollments, and a resulting shortage of qualified earth science teachers in many states (Helgeson *et al.*, 1977, p. 24).

Table 2-7. Total Enrollment in Grades 7-12

	1961	1973	Percent Increase
	11,700,000	18,500,000	59%

Table 2-7. (continued)

Number of Public School Students in Grades 9-12 Enrolled in Specific Science Courses in Selected Years

Course	1961	1973	Percent Change
General Science	1,826,087	1,096,020	−40%
Biology	1,776,306	2,868,352	+61%
Physiology	65,953	109,588	+ 66%
Earth Science	76,564	558,654	+630%
Chemistry	744,820	1,028,591	+38%
Physics	402,317	583,105	+45%

Source: National Center for Education Statistics, 1976, p. 8 and Helgeson *et al.*, 1977, p. 27.

In the 1960s, courses in physical science began to be offered at the eighth, ninth, and tenth grade levels for students who did not take chemistry or physics, or as preparation for these courses. About half of the schools were offering these general physical science courses in the 1960s, but since 1970 the percentage of students enrolling in them has declined (Helgeson *et al*, 1977, p. 29).

Course enrollment statistics collected by the National Center for Educational Statistics (NCES) 1972-73 survey indicate that the percentage of high school students (grades 9-12) registered in any science course increased from 48 percent in 1949 to 66 percent in 1960-61, and increased slightly further to 67.2 percent in 1972-73 (Ostendorf and Hern, 1976, p. 14). State data reviewed by Helgeson *et al*, (1977, p. 26) indicate a small reduction in the percentage of high school students taking science courses during the period 1974 to 1976.

The numbers of students enrolled in selected science courses according to the NCES surveys are listed in Table 2-7. Biology, usually taken in grade 10, is the last science course taken by about half of the students. The NSF science education literature review indicates that in most states over 80 percent of the students enroll in a biology course sometime during their high school program (Helgeson *et al*, 1977, p. 26).

Helgeson *et al*, without citing a source of data, state that chemistry enrollments showed a small percentage of enrollment gain in the 1960s and early 1970s, but that since 1971 the percentage of students enrolled in chemistry appears to have declined slightly. In addition, their report states that the percentage of enrollments in physics increased slightly in the 1960s and early 1970s, and has decreased since 1971-1972 (1977, p. 28).

However, the percent change calculations shown in Table 2-7 indicate that although enrollments in high school chemistry and physics courses did increase, they did not keep pace with the larger increase in the total secondary school student population during the period 1961 to 1972.

Percentage enrollments in advanced science courses (second-year biology, chemistry, and physics) and science electives such as physiology, anatomy, zoology, botany, oceanography, and ecology have increased during the last five years. Such science electives seem to be absorbing significant numbers of students who opt not to take chemistry and/or physics. Advanced or second-year biology courses have shown the largest percentage gains; it appears that as many as 3 percent of the students in grades 10, 11, and 12 are enrolling in such courses (Helgeson *et al*, 1977, p. 29).

Mathematics. In 1949, 65 percent of the secondary school students in grades 7-12 were enrolled in a mathematics course. This figure increased to 73 percent in 1960, and then decreased slightly to 71 percent in 1972-73 (Ostendorf and Horn, 1976; Wright 1965).

Commenting on the effects of the secondary-level mathematics curriculum efforts during the period 1955-1975, the National Advisory Committee of Mathematics Education (NACOME) Report (1975, p. 6) notes that there were increased offerings in 1960 in advanced general mathematics, plane geometry, advanced algebra, trigonometry, and advanced mathematics courses such as calculus, probability and statistics, and analytic geometry. The 1972-73 NCES survey data revealed that almost as many students were taking a second course in algebra or algebra/trigonometry as were taking elementary algebra and that cover 260,000 high school students were studying calculus or other advanced-level mathematics courses, four times the 1960 figure. The 1972-73 NCES survey thus indicated that changes had occurred in the mathematics curriculum for a targeted but narrow sample of secondary mathematics students; changes for students who were not as interested in mathematics were less pronounced (NACOME, 1975, p. 5).

Summarizing the results of several more recent surveys, the NSF mathematics education literature review concluded that the mathematics enrollment pattern has been relatively stable in recent years, but that some declines have been noted. In New York State, for example, enrollment has declined slightly year by year during the period 1971 to 1976 in the introductory mathematics and algebra courses generally taken by most high school students, although the enrollment has increased in ninth grade "basic mathematics" (Suydam and Osborne, 1977, p. 44).

Social Studies. Citing a study by Gross, the authors of the NSF social studies education literature review examined social studies course enrollment trends from 1961 to 1973; these data can be found in Table 2-8, which shows the percentage change in enrollment for the most commonly offered social studies courses.

It can be seen that enrollments in U.S. history and U.S. government grew a little more rapidly than total enrollment during the 1961 to 1973 period, but that enrollments in world history and world geography grew less rapidly. The enrollment decreases in some courses were apparently redirected to new social studies offerings, particularly elective courses in the social sciences such as psychology and sociology (Wiley and Race, 1977, pp. 35-36).

Use of Federally Funded Curricula

The NSF case studies investigators did not find much evidence of the laboratory-oriented NSF science curriculum projects in the schools, nor did they identify any remnants of the "new math" programs developed with NSF support. In social studies, no traces were found of the High School Geography Project, Project Social Studies, the Anthropology

Table 2-8. Total Enrollments in Grades 7-12

	1961	1973	Percent Increase
	11,700,000	18,500,000	59%

Number of Public School Students in Grades 9-12
Enrolled in Specific Social Studies Courses in Selected Years

Course	1961	1973	Percent Change
Civics	733,000	449,000	−39%
Problems of Democracy	380,000	298,000	−22%
World History	1,471,000	1,541,000	+ 5%
World Geography	595,000	736,000	+ 24%
U.S. Government	780,000	1,306,000	+ 67%
U.S. History	1,994,000	3,464,000	+ 74%
Economics	293,000	592,000	+102%
Sociology	289,000	796,000	+175%
Psychology	140,000	590,000	+323%

Source: Wiley and Race, 1977, p. 35 (after Gross).

Project, etc. (Stake and Easley, pp. 13:7, 13:23, 13:29b).

Whether or not these observations are accurate or are representative of the situation in the rest of the schools in the United States is open to question. It is possible that at least some of the observers utilized by the NSF case studies may not have been equally familiar with the previous NSF curriculum development efforts in all subject areas, and therefore may not have recognized any residue of impact. Nevertheless, their impressions are discouraging.

The NSF statistical survey did obtain estimates of the percentages of school districts and teachers who indicated use of specific federally funded materials during the 1976-77 school year, and also obtained information on the use of these materials by districts and teachers in prior years. The results for the most commonly used materials are summarized in Table 2-9.

Again, as was the case at the elementary level, the figures for mathematics may be misleading, since most federally funded mathematics materials were developed with the intention of incorporating the innovations into commercially developed text books. It is unfortunate that neither the NSF statistical survey nor the NSF case studies made an attempt to assess the impact of any specific innovations of the secondary level mathematics curriculum development projects.

Table 2-10 indicates the percent of secondary school teachers in each subject and grade range who were using at least one of the federally funded project materials. (Note that only the most commonly used, federally funded materials are listed in Table 2-9.)

Table 2-9. Use of Selected Federally Funded Curriculum Materials (Grades 7-12)

	Percent of School Districts Using Selected Materials		Percent of Teachers Using Selected Materials			
			Grades 7-9		Grades 10-12	
Curriculum Material	Using In 1976-77	Used Prior to 1976-77	Using In 1976-77	Used Prior to 1976-77	Using In 1976-77	Used Prior to 1976-77
Science						
BSCS Green	19	30	3	14	17	30
BSCS Yellow	16	31	5	14	13	31
BSCS Blue	8	11	6	11	5	16
Chemical Bond Approach	2	3	0	2	2	5
CHEM Study	15	19	1	5	7	14
ESCP	10	12	10	22	4	10
IPS	25	21	9	23	7	29
ISCS	12	11	12	19	2	6
PSSC Physics	11	18	1	4	4	14
Project Physics	12	9	1	4	10	14
Mathematics						
IMS	2	4	3	7	1	3
Modern Coordinate Geometry	3	3	3	6	5	13
SMSG	2	18	7	26	6	31
Social Studies						
American Political Behavior	12	11	3	6	7	12
Carnegie Mellon Project	10	11	2	4	4	12
High School Geography Project	4	7	2	4	3	7
Sociological Resources for the Social Studies	7	7	1	3	6	10

Source: Weiss, 1978, pp. B-21, B-23, B-25, B-37, B-39, B-41.

Comparing these data with Table 2-3, it will be noted that secondary school teachers were much more likely than elementary school teachers to be using one or more of the federally funded materials.

Table 2-10. Percent of Secondary School Teachers Using One or More of the Federally Funded Curriculum Materials in Each Subject by Grade Range (1976-77)

	Subject		
	Science	Mathematics	Social Studies
7-9	33	10	12
10-12	52	11	22

Source: Weiss, 1978, p. 83.

Table 2-10 also indicates that the percentage of science teachers using federally funded materials was greater than the percentage of mathematics or social studies teachers. Slightly more than half of all grade 10-12 science teachers were using at least one of the federally funded curriculum materials during the 1976-77 school year. It is difficult to reconcile this information with the previously cited observations of the NSF case studies.

It is important to note that Table 2-9 does not give data about the percentages of **teachers teaching a given subject** who were using the materials. However, analysts did make some rough estimates of this kind and determined that approximately half of all biology teachers were using at least one of the BSCS materials; approximately 40 percent of all physics teachers were using either the Project Physics Course or PSSC Physics or both; and approximately 25 percent of the chemistry teachers were using either CHEM study materials or the Chemical Bond Approach, or both (Weiss, 1978, p. 82).

The data collected by the NSF statistical survey indicate that a number of the federally funded materials were used more extensively by teachers in previous years than in 1976-77, particularly SMSG for K-12 mathematics; PSSC physics, CHEM Study chemistry, and several of the BSCS program materials in 7-12 science; and *Our Working World* in K-6 social studies.

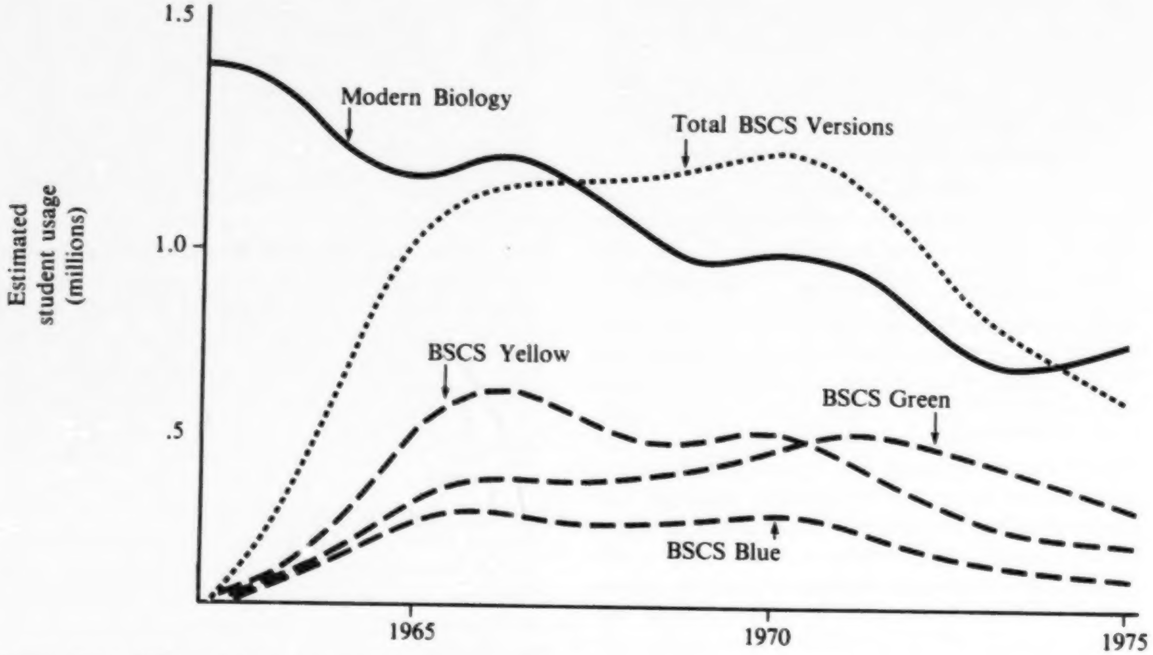
Tracing the use of the PSSC physics program, Helgeson *et al* (1977, p. 28) note that the major physics text in use in the late 1950s was *Modern Physics* (Holt). Introduced in 1958, PSSC gained in acceptance until the early 1970s, at which time the peak usage was about 35 percent of the students enrolled in physics. Since the early 1970s, the use of PSSC has been declining, as reflected in the NSF statistical survey results. Project Physics, introduced in 1969, accounted for approximately 22 percent of the students studying physics in 1975. However, *Modern Physics* continued to be used by over 40 percent of the students throughout this time period (Helgeson *et al*, 1977, p. 29).

The situation in chemistry was similar. In the late 1950s most high school chemistry students were using *Modern Chemistry* (also published by Holt). Of the two NSF-funded high school chemistry projects, the *Chemical Bond Approach* (CBA) never was used by a large number of schools, but the CHEM Study text received considerable acceptance during the 1960s. The use of CHEM Study materials peaked in the early 1970s at about 30 percent of the students taking chemistry; this was followed by a decline during the last four years. Helgeson *et al* suggest that this decline was due primarily to the availability of other texts that incorporate many of the CHEM Study approaches. However, the *Modern Chemistry* text, like the Holt physics text, has continued to be widely used. Helgeson *et al* (1977, p. 28) report that in 1974 about 50 percent of the high school students studying chemistry were using this text.

In biology, the major text used during the 1950s was also one published by Holt, *Modern Biology*. Prior to 1963, it was reputed to occupy 80 percent of the high school biology market (Quick, 1978, p. 118). The three BSCS biology programs (the green, yellow, and blue versions) were widely adopted by school systems during the 1960s. In the early 1970s, about 40 percent of the students studying biology were using one of the three BSCS versions; about 35-40 percent were using the *Modern Biology* text. More recent data, as well as the NSF statistical survey, indicate that there has been a decline of from 5 to 8 percent in the use of the BSCS materials in recent years (Helgeson *et al*, 1977, p. 26). Figure 2-1 provides a picture of these trends in biology textbook usage.

A number of observers have stressed that recent declines in usage of federally funded innovative materials need not cause much concern, since many of the ideas and approaches of these innovative materials have been incorporated into "conventional" textbooks (Weiss, 1978, p. 78; Helgeson *et al*, 1977, p. 28). Quick, in her recent study of the

Figure 2-1. Student Usage of Biology Textbooks



Source: Quick, 1978, p. 119. Student usage was estimated by John G. Wirt of the Rand Corporation from sales data supplied by Holt, Rinehart, and Winston, Inc., New York, and BSCS, Inc., Boulder, Colorado.

secondary impacts of the curriculum reform movement, found consistent evidence that educational publishers had incorporated innovations of the federally funded curriculum materials into their own commercially developed programs. She suggests that the commercial success of the federally funded programs created market pressures that encouraged publishers to incorporate some of the themes and approaches of the innovative materials (Quick, 1978).

Other observers are less sanguine than Quick about the impact of the federally funded innovative programs on classroom instruction in schools that are now using commercially developed texts. Many of these texts have adopted changes that are largely cosmetic, in order to reflect the "inquiry approach" and other innovations of the curriculum reform movement. Most of these commercially developed texts still lend themselves to being used to support a didactic approach to teaching in which the student's main role is to listen, read, and memorize.

However, the above data indicate that a substantial number of teachers do continue to use the inquiry-based curriculum materials developed with federal support, although they usually constitute a minority. Of greater concern is the rate at which this usage is decreasing, especially considering the absence of an effective mechanism to familiarize new teachers with the content and approach of the NSF courses.

Factors Affecting the Quality of Instruction

Evidence of a Decline in Student Performance

In 1977, after a 14-year decline, the average scores on the College Entrance Examination Board's (CEEB) verbal and mathematics tests reached a new low. The Scholastic Aptitude Test (SAT) verbal score average, which had been 478 in 1963, dropped 49 points to 429; the mathematics average score fell from 502 in 1963 to 470 in 1977. A CEEB panel investigating the decline estimated that about 70 percent of the decline prior to 1970 was due to an expansion in the diversity of the population of students taking the SAT. In

1952, only half of the young people in the United States were staying in school through the twelfth grade; this increased to two-thirds in 1964, and to three-fourths in 1970. The proportion going on to college was about one-fourth in 1952; this increased to one-third in 1964 and to almost half in 1970. The panel indicated that 55 percent of those taking the SAT in 1960 came from the top fifth of their high school classes; in 1972 this was true of only 36 percent (Wirtz *et al*, 1977, pp. 13-14).

However, since 1970 there has been only a limited amount of change in the composition of the test-taking group. The CEEB panel suggested that a number of other factors might have affected the scores, including: (1) a proliferation in the number of elective courses taken by high school students at the expense of more "basic" course offerings; (2) a "diminished seriousness of purpose and attention to mastery of skills and knowledge . . . in the schools, the home, and the society generally"; (3) the competition for time between television and students' school work; (4) a decline in the role of the family in the educational process; (5) the effect of a "decade of distraction" between 1967 and 1975; (6) "an apparent marked diminution in young people's learning motivation."

Ironically, the CEEB panel laid some of the blame for the decline in the SAT scores on a deterioration in student writing ability, brought about in part by the increasingly widespread use of easily scored multiple-choice tests (like the SAT) at all educational levels:

> *Our firmest conclusion is that the critical factors in the relationship between curricular change and the SAT scores are (1) that less thoughtful and critical reading is now being demanded and done, and (2) that careful writing has apparently about gone out of style. . . . We can't prove that learning how to write is related to a decline in scores on a test that requires no writing. Yet in our judgment this may be a significant factor. We suspect strongly that expressing something clearly and correctly—especially in writing—is thinking's sternest discipline.*
>
> *It seems clear that increasing reliance in colleges and high schools on tests requiring only the putting of X's in boxes contributes to juvenile writing delinquency. Students learn what they think they need to know. . . . Our strong conviction is that concern about declining SAT Verbal scores can profitably be concentrated on seeing to it that young people do more reading that enhances vocabulary and enlarges knowledge and experience, and more writing that makes fledgling ideas test and strengthen their wings (Wirtz et al*, 1977, p. 27).

Although the "return to the basics" has shifted into high gear in school systems throughout the United States it is paradoxical that this activity has been accompanied in many school districts by an increased molecularization of the curriculum into disembodied learning objectives, the achievement of which is usually indicated by student performance on standardized or criterion-referenced multiple-choice tests. Too often, these tests emphasize the most superficial aspects of learning in the content areas, focusing on the recall of conceptual schemes.

More detailed information about student performance in specific disciplines has been provided by the surveys conducted in recent years by the National Assessment of Educational Process (NAEP). The first NAEP mathematics assessment was conducted during 1972-73, and included six major content areas: numbers and numeration, measurement, geometry, variables and relationships, probability and statistics, and consumer mathematics.

Summarizing several interpretive reports on the results of the 1972-73 mathematics assessment, Suydam and Osborne (1977, pp. 201-203) indicate that student performance was reasonably strong in the areas of whole-number computation, knowledge of numeration concepts, analysis of one-step word problems, measurement concepts, and the recognition of basic geometrical figures. Weaknesses were evident in the areas of percent, the use of fractions, tasks involving estimation and measurement, problems involving geometrical concepts, and complex word problems.

Three NAEP science assessments have been conducted (in 1969-70, 1972-73, and 1976-77) to assess the science knowledge of nine-, thirteen-, and seventeen-year-old students. A considerable amount of controversy has been generated concerning both the kinds of questions included in the first two surveys and the way in which the results were reported to the public (Tolman, 1976). An attempt was made to revise the NAEP science test items and reporting procedures for the 1976-77 science assessment in order to remedy these problems.

A statistically significant decline in achievement on the test exercises was noted between the first and second science assessments for all three age levels. A further decline was noted for seventeen-year-olds in 1976-77; their average scores were lower on both biology and physical sciences exercises, although the decline was greater in the physical sciences. Nine- and thirteen-year-olds did not decline in achievement on biology exercises during the period 1969-1977, but both groups did decline steadily in achievement on physical science questions (NAEP, 1978b).

In 1971-72, the first NAEP social studies assessment was conducted. The following findings were highlighted in the report of this survey:

> Less than one-half of the seventeen-year-olds and adults in the nation understood how to use all parts of a simple ballot.
>
> Relatively few Americans could read or interpret tables, graphs or maps effectively.
>
> A large gap existed between the attitudes students professed to hold and the actions they indicated they would take in specific situations.
>
> Exercises involving the recall of specific information appeared to be the most difficult to answer for all age groups.
>
> Students generally had very little knowledge about the contributions of minority groups to our culture and history.

The 1971-72 social studies results also suggested that one's out-of-school learning experiences in social studies are often as important as what one learns in school (Wiley and Race, 1977, p. 212).

A second NAEP social studies assessment was conducted in 1975-76. This survey provided data on changes in social studies achievement between 1972 and 1976. The results revealed changes in social studies achievement that were related to age level: nine-year-olds showed no statistically significant change in performance while the achievement of thirteen-year-olds declined only slightly. However, the performance of seventeen-year-olds showed a significant decline between 1972 and 1976 (NAEP, 1978a). In this respect the results of the 1976 social studies assessment and the 1977 science assessment were similar, and suggest that special attention needs to be paid to changes in attitudes toward learning that may be occurring when students reach adolescence, and to the methods which teachers are using to deal with this problem.

Teacher Effectiveness in the Classroom

TEACHER QUALIFICATIONS

The NSF statistical survey determined that, considering science, mathematics, and social studies teachers as a group, the average number of years of teaching experience is 11.5 years, with only small differences among those responsible for different subjects or grade levels (Weiss, 1978, p. 137). Although many school systems are experiencing declining enrollments, union pressures and the desires of school system administrators to avoid grievances have led to the establishment of reduction in force policies based solely on seniority. As a result, it has generally been the younger teachers who have been dropped when personnel cuts become necessary. The more experienced teachers have been retained, sometimes by transferring them to different grade levels or sometimes to entirely new subjects.

Most secondary (levels 7-12) school teachers of science, mathematics, and social studies teach all of their courses within a single subject area. However, 13 percent of the secondary science teachers surveyed were teaching one or more courses for which they felt inadequately qualified, as did 12 percent of the social studies teachers and 8 percent of the mathematics teachers. Most such teachers indicated concern about their qualifications to teach courses within their general subject area; for example, a science teacher qualified to teach biology might have indicated a concern about being unqualified to teach earth science or chemistry (Weiss, 1978, p. 142).

At the elementary level, 49 percent of the teachers feel themselves to be "very well qualified" to teach mathematics, as compared to 39 percent in social studies, only 22 percent in science, and a high of 63 percent in reading. Most of the teachers felt at least "adequately qualified" to teach all these subjects, although 16 percent of the elementary teachers felt that they were "not well qualified" to teach science, the only subject in which more than 6 percent of the teachers so indicated (Weiss, 1978, p. 142). However, state science supervisors and elementary school principals considered inadequate teacher preparation in science, as well as a lack of teacher interest in science, to be a serious problem in their schools. In addition, state mathematics supervisors rated inadequate teacher preparaton to be a serious problem in K-6 mathematics (Weiss, 1978, p. 161l).

In the past, the NSF provided a considerable amount of support for inservice training institutes to help teachers to improve their knowledge of subject matter and teaching skills. Almost half of the grade 10-12 science teachers, and 40 percent of the mathematics teachers at this level, have attended one or more of the institutes, conferences, or workshops sponsored by NSF. Attendance rates at such NSF activities were substantially lower for junior high school science and mathematics teachers (grades 7-9) and much lower for elementary school teachers, averaging less than 10 percent for science and 5 percent for mathematics. Only a few of the social studies teachers surveyed had attended NSF institutes or workshops; this is not surprising since NSF sponsored a relatively small number of such inservice training activities in the social sciences (Weiss, 1978, p. 69.

Although the teacher training institutes supported by the National Science Foundation were attended by significant numbers of teachers, half of the science, mathematics, and social studies teachers surveyed in 1977 indicated that they needed assistance in the use of manipulatives or hands-on materials in implementing the inquiry approach (Weiss, 1978, p. 148). Undoubtedly, this group included many experienced teachers who have been reassigned to teach subjects outside of their field of expertise, as well as new graduates from colleges of education who are currently receiving very little training in the use of specific inquiry-based course materials. The NSF case studies reported that many teachers and administrators felt that the NSF institutes should be extended to the many teachers who have not had a chance to benefit from them (Helgeson, Stake, and Weiss, 1978, p. 19:25).

Unfortunately, there are not as many opportunities as there once were for teachers to improve their knowledge of subject matter and their teaching skills. Local school systems do not have the resources or capabilities to support such activities; the limited staff development funds that are available are usually targeted on efforts to implement competency-based accountability schemes. Since in the past such training was most effectively provided in the context of course-specific NSF institutes, the Foundation's current inability to support such activities poses a serious problem.

LABORATORY INSTRUCTION AND THE INQUIRY APPROACH

The research scholars and teachers who worked together in the NSF Course Content Improvement Program were critical of the encyclopedic approach of the textbooks of the time and of the procedures by which facts were presented, facts were learned, and facts were regurgitated in class and on examinations. Instead, the developers of the new courses strove to create teaching materials that would foster better understanding of ideas and principles. They placed emphasis on what is called the inquiry approach, which provides opportunities for students to "discover" key concepts and relationships through hands-on experiences. Thus laboratory instruction was designed to play an important role in the NSF-supported curricula, especially in the sciences. There are many reasons for such an emphasis.

First, laboratory work provides personal experiences for students. Some of the programs were designed so that important information had to come from the lab. The development of an idea in the textbook would stop at a critical point, requiring the student to search for the answer in the laboratory. Students were expected to be able to answer some important questions on the basis of their own observations and experiments.

Second, laboratory experiences provided information that is almost impossible to convey in a textbook. Printed words and static illustrations cannot capture the complexity of the behavior of microorganisms in a droplet of pond water or of the ways in which waves passing through two narrow aperatures interact to produce interference patterns.

Third, the laboratory requires activity of students in a time when many young people lead increasingly passive lives. For some young people, the dissection of a frog or the qualitative analysis of an unknown substance will be one of the most challenging things they have ever done in their lives.

Fourth, scientific observations and experiments frequently show the limitations and uncertainties of scientific procedures. All copies of the same book present the same "correct" data and answers. Observations and experiments may not and, when the results are different, an inquisitive student and a stimulating teacher will search for the causes of the different results. That search will lead to a deeper and more reliable understanding of the phenomenon.

Lastly, most students find that laboratory work is fun. The seemingly endless pattern of classroom recitation or busy work is broken by this opportunity to be independent, to be active, and to discover.

However, the use of laboratory instruction and the inquiry approach in the schools appears to be diminishing. Although the use of manipulatives or laboratory materials is much more common in science classes than in mathematics or social studies classes, only 48 percent of the (K-12) science teachers surveyed indicated that they used them once a week or more in their classes, 9 percent of the K-12 science classes never use laboratory materials, and 14 percent do so less than once a month (Weiss, 1978, p. 107). Although the use of laboratory materials is more common at the secondary level, the NSF statistical survey revealed that 26 percent of the level 10-12 science classes and 38 percent of the level 7-9 science classes do not have laboratory activities as often as once a week (Weiss, 1978, p. B-62).

In some schools, this reduction in "hands-on" learning experiences can be attributed to a lack of laboratory facilities and equipment, since the diminishing proportion of school district funds allocated to instructional supplies and equipment is causing critical shortages of laboratory apparatus in many school systems. This problem has been exacerbated by the termination of categorical National Defense Education Act support for the purchase of science equipment and the improvement of laboratory facilities. The NSF statistical survey revealed that shortages of science supplies and equipment were identified as a major problem by over one-third of the secondary school science teachers and by over half of the elementary teachers of grades 4-6 (Weiss, 1978, p. 135). The situation at the elementary level is encapsulated in this comment by a science coordinator quoted in the NSF case studies:

> *Even though state law says teach science as a lab science, with so little money you have to teach it from the textbook. At the elementary level many teachers cannot teach science and many do not try (Stake and Easley, 1978, p. 13:6l).*

A second factor which must be considered as a possible cause of the infrequent use of laboratory instruction is the decreased opportunities during recent years for teachers to attend NSF institutes focused on specific laboratory-centered courses. The NSF statistical survey indicated that science teachers who had attended one or more NSF-sponsored institutes were considerably more likely than other teachers to be using manipulative materials once a week or more (Weiss, 1978, p. 107). Because laboratory-centered courses are more difficult to teach, the problems which inevitably arise when an untrained teacher attempts to use inquiry-based materials often lead to the adoption of a textbook-centered approach which makes fewer demands upon the teacher.

However, even if teachers have been adequately trained and provided with sufficient laboratory equipment and supplies, forces still remain that tend to discourage placing an emphasis on hands-on learning experiences. The educational climate in the schools, with the current focus on accountability schemes and basic skills, has tended to attach great importance to student performance on standardized achievement tests or criterion-referenced competency tests. Because complex ideas and relationships are difficult to test in a multiple-choice format, a heavy system-wide emphasis on multiple-choice testing has the unfortunate result of elevating the importance of the simpler and less meaningful instructional objectives and of diminishing the importance attached to the learning of concepts and relationships.

Teachers and principals are under pressure to allocate more and more instructional time to the kinds of achievement measured by the tests, and to neglect those aspects of student learning that are not so well measured by the tests. Principals and teachers who advocate learning through experience find little to sustain them in such an environment.

The Educational Climate in the Schools

The diminished emphasis on laboratory instruction and learning through experience is thus indicative of a more pervasive problem in the nation's public schools. The whole climate under which teachers are working is less favorable to the pursuit of excellence than it was in the latter part of the 1950s and most of the 1960s.

Science and the development of critical thinking skills in social studies and mathematics have assumed a low priority in the thinking of school administrators. An increased emphasis on the "basic" learning skills, such as reading, arithmetic, and spelling, is preempting time previously available for the study of science. social studies, and mathematical concepts, especially in elementary schools. The NSF case studies observers found that in most schools natural sciences, mathematics other than basic arithmetic, and social science inquiry were seen as having a rather limited value for the student body at large, and that providing a strong K-12 program in science for those students who will become the nation's future scientists was not a high priority in most school systems (Stake and Easley, 1978, p. 12:1).

The NSF case studies observers also found much apathy among students. In some schools, a lack of academic motivation was revealed by low attendance rates and the refusal of many students to attend school on a regular basis. Other students displayed their apathy towards school through passive noninvolvement in classroom activities. After budget problems, the problem most frequently cited by public school teachers was student apathy, lack of motivation, and absenteeism (Stake and Easley, 1978, p. 18:89).

The NSF case studies described many of the schools as not being intellectually stimulating places in which to work. Few school principals have a good academic background in science or mathematics; this makes it difficult for them to help teachers to develop effective science and mathematics instructional programs. School administrators have increasingly had to become managers and interpreters of the school bureaucracy, rather than educational leaders. School system superintendents, primarily preoccupied with the details of institutional management, are not acting as educational spokesmen, but instead are responding primarily to perceived community and governmental pressures.

This is not the set of conditions one would choose as the environment in which to mount new efforts to improve science and mathematics education. However, many opportunities remain to cooperate with that nucleus of teachers who retain the spirit of the course content improvement program and to expand their numbers. Many teachers would take advantage of a revived program of NSF institutes and many say that they want access to knowledgeable resource people who can help them with their teaching problems in science and mathematics. Scientists and research scholars in all fields need to address this problem, and to find ways in which they can cooperate to provide the educational leadership that is so critically needed.

The Current Need

That volunteer citizen initiative can secure substantial and constructive change in the classrooms of America was generously demonstrated by the impact of the National Science Foundation's Course Content Improvement Program. Some 53 different curriculum-development projects were carried through by volunteer groups of university scientists and experienced teachers. Beginning with the Physical Sciences Study Committee of 1956, the effort spread to the life sciences, chemistry, mathematics, and the social sciences, principally for the secondary school years but also including new programs and materials for the elementary grades. By the mid-1960s, improvements in the preparation of entering freshmen compelled upgrading of the science curricula in the colleges. In 1978, nearly a decade after the main initiative had been spent, more than half the high-school science teachers surveyed were still using "at least one" of the materials thus developed, as were 22 percent of the teachers in the social sciences and 11 percent of the teachers of mathematics. The cumulative cost to the taxpayer of this movement in American education came to just under $1 billion, most of it spent for teacher institutes that brought teachers back to college for refresher courses in their subjects as well as introducing them to the new curricular materials. It would be difficult to find a better bargain in the federal government's shopping list over the past quarter century.

The effort that started in the 1950s was motivated by fear that the United States was falling behind in international competition and by the conviction that it was necessary to increase the number of young people preparing for careers in science and technology.

Now, the disarray in American elementary and secondary schools again asks for the concern and the constructive intervention of all responsible citizens. Much evidence indicates that far too many young men and women are leaving high school with less than an adequate capacity to read, write, and do simple arithmetic. Such findings have enlisted many citizens and educators in a nationwide "back to the basics" movement, with a resulting narrowing of the educational program in schools all across the country.

From the preoccupation of the popular culture with the paranormal, the psychic, the mystic, and the occult, it is apparent that an alarming number of American adults cannot tell sense from nonsense. Mathophobia and the associated incapacity to make rigorous quantitative connections and distinctions afflicts altogether too large a fraction of the adult population. In the context of single purpose pressure groups in contemporary politics, wishing displaces thinking; none of these groups accepts the real-world constraint that allows the attainment of each good only in a trade-off against some other good. The American people share no common body of knowledge and understanding on which to ground a reliable consensus on such urgent public issues as energy and the arms race. Too many Americans find themselves coping with life in today's largely man-made environment with relatively as much ignorance and superstition as forerunners in the pristine environment of nature.

The situation argues for literacy in science as an objective of American education fully as urgent as basic skills in the three R's. An educated citizen ought to have not only a general acquaintance with contemporary knowledge about inanimate and living nature but, more important, a disposition and capacity to frame questions and find answers. One must be able to recognize relevant evidence, make quantitative assessments of rate and scale, and think in rational accordance with objective reality. Some methods of teaching science can contribute to the development of this kind of critical, rational approach to problems; and a reasonably accurate but not detailed understanding of major scientific principles and of the methods and limitations of scientific work—what we here call scientific literacy—can help one to understand and cope with many types of problems.

To assert the priority of scientific literacy is not, therefore, to attempt to impose upon American education the aims of yet another single-purpose pressure group. On the contrary, it is a call on American society to redeem its promise to its children: that is, to fulfill their right to the best education society can provide.

That right is implicit in the very institution of democratic self-government. A self-governing society must be made up of self-governing citizens. What is wanted in the citizen is autonomous intelligence, disciplined to seek and face the truth, and capable of the independent judgment that stands up both to wishful thinking and to arbitrary external authority.

The liberating objective of scientific literacy cannot be accomplished by a one-time effort, not even one as prolonged as the course content improvement effort. What is required is the permanent, sustained, and increasing commitment of the American scientific community to enlarge its presence in the nation's classrooms. A practical and feasible program to this end, one that will reach a substantial and reasonable number of classrooms and children in a reasonable time, is spelled out in what follows.

There is not now as much public interest in improving the quality of education as there was during the early post-Sputnik years and many scientists may now be less willing to take time away from their regular duties than were eager to volunteer in the 1950s and 1960s. Even so, we expect that university and industrial scientists and engineers, and others qualified to help, will make themselves available for the effort, which will range from curriculum development, to the instruction of classroom teachers, to the development of regional resource centers, and to helping teachers in the classroom. That such talent and time are available, providing there is assurance the effort can be effective, was demonstrated by the story of the science-curriculum reform movement of the 1950s and 1960s.

It is also expected that the National Science Foundation will correspondingly restore elementary and secondary science education to its priorities, and will have funding available to respond to proposals, subject to the usual critical standards of peer review. Additional funding will be necessary from other sources, for while NSF can be a leader, it should not be expected to provide all of the necessary money. We make no estimate of the total cost of the following recommendations. Those costs will be variable, depending upon how widely the recommendations are adopted. But even at full implementation, annual costs would be substantially less than one percent of the $100 billion per year that federal, state, and local governments now spend on elementary and secondary education.

Recommendations

Rationale

The Panel's recommendations are based on three considerations:

> An analysis of the alternative goals of precollege education in science and mathematics.
>
> Lessons learned from experience with the new courses and curricula of the 1950s and 1960s.
>
> Evidence from teachers as to what they need in order to teach more effectively.

THE GOALS OF SCIENCE AND MATHEMATICS EDUCATION

There are four main goals for the teaching of science and mathematics:

1. Knowledge is a value in itself. It need serve no immediately useful purpose other than to expand the world view of the individual learner.

2. Knowledge may be useful by helping the individual to live in greater health and happiness, and even to survive better in a competitive society.

3. Important economic and social values are involved. Citizens with knowledge of science and mathematics are necessary for a healthy economy and for future progress; and intelligent action on many public issues depends upon understanding their scientific and technical content.

4. The education may be preparatory to a professional career in science or one of the technical professions.

The major NSF-supported curriculum studies were initiated primarily to deal with the fourth goal, to help increase the nation's scientific manpower. Because there were at the same time a number of other measures to that same end, it is impossible to say just how much the Course Content Improvement Program contributed to the growing numbers of scientists and engineers. But it is clear that their number did increase greatly and that the new courses developed under NSF auspices did provide improved learning materials for a significant number of students who were interested in careers in science and mathematics. Moreover the high visibility of the new courses drew added attention to their disciplines.

Because the new curricula were designed for precollege students, and especially for high school students, they could only be introductory, and not fully professional. Thus for a large group of students, including many who were not headed toward scientific or technical careers, they served the other goals as well. They did so to varying degrees.

The first goal—learning for the sake of learning—was met with considerable success. The science curricula were modern, laboratory based, and inquiry-oriented. They were sophisticated and demanded considerable mental work from the student. They were indeed mind-expanding for students who were motivated, able, and disciplined, and who were fortunate in having a skillful teacher and a well-equipped laboratory.

The second goal—knowledge useful for one's own well-being—was met less successfully. As an example, the biological sciences can offer much of importance to one's health and happiness: an understanding of nutrition, disease and its prevention, and behavior. Yet the Biological Sciences Curriculum Study courses did not deal with these areas in a substantial manner; there were other messages that seemed more pressing to the authors. A second example is provided by the new elementary school mathematics. It may have introduced young pupils to the field of mathematics in a manner thought befitting by mathematicians, but it did not succeed in encouraging students to become "friendly with numbers" and it left some of them unable to do the simple calculations of adult living.

The third goal—an informed citizenry—was probably the least successfully met. It is unquestionably difficult in one school year to give students an understanding of the basic scientific concepts in a field and also to provide enough relevant information to enable them as future citizens to deal intelligently with difficult political, economic, and social issues. But progress can be made; students can begin to develop critical standards that will help them to sort out and appraise the technological claims and advice they receive through the popular media. This task has not been given sufficient attention in past curriculum development efforts and needs to be readdressed.

In summary, goals two and three—knowledge useful for one's own well being and knowledge useful for good citizenship—now need more emphasis than they received in the 1950s and 1960s.

LESSONS OF THE PAST

In planning future programs, we should take advantage of the experience of the past two decades of curriculum reform. That experience has demonstrated that even the best curriculum materials will not be adequately utilized unless attention is paid to the following issues:

1. Teachers must be provided opportunities and incentives to acquire the comprehensive training necessary for the successful utilization of the new materials and techniques.

2. Principals should be provided opportunities to gain understanding of the new programs, for they are key agents for educational change or for maintaining the status quo.

3. New course materials should be introduced in a fashion that encourages honest exchange of views between teachers and the exponents of curricular innovation.

4. Mechanisms of long-term materials support must be established so that teachers can obtain the instructional materials and apparatus needed for the new

courses. In the past, obtaining materials has presented a serious obstacle to the successful adoption of elementary science programs, for many of those programs utilize a large variety of expendable materials. Although commercially-prepared kits have been purchased by many school systems, elementary teachers in particular, have found it difficult to order in advance all of the materials required to refurbish those kits so they may be used again.

5. Resource personnel should be available to provide continued expert advice and moral support to teachers and principals when problems arise. The three NSF studies indicate that most school systems are not sufficiently staffed with supervisory personnel to perform this task. Such supervisory personnel as exist are usually so fully occupied with administrative functions that they seldom have opportunities to work with the large numbers of teachers for whom they are responsible.

WHAT TEACHERS NEED

Many teachers want help. They want to teach more effectively. They want better equipment that will help their students learn from observation, manipulation, and trying things out—from educative experience as well as from reading and discussion. They want to strengthen their own understanding of science and mathematics. And they want access to experts to whom they can turn for help on their teaching problems (Weiss, 1978, pp. B-93-B-116; Stake and Easley, 1978).

The percentages of teachers expressing each need varied considerably, depending on the subjects taught and the age level of the pupils involved, but in total, large numbers of teachers said they wanted improvement in each of the following areas:

> Opportunities to learn about new teaching materials.
>
> Access to current information in their fields.
>
> Opportunities to learn new teaching methods, especially regarding the use of "hands-on" materials and the implementation of the discovery or inquiry approach.
>
> More permanent equipment, such as microscopes or balances, and better maintenance of equipment.
>
> Ability to get consumable supplies such as chemicals, dry cells, and duplicating masters quickly and as needed.

The teachers who want these improvements are to be found in many school systems. They are sometimes a minority within their own school system, but in total, there are many of them. Because the teachers who want these kinds of help are widely scattered and because no central education authority exists under the American system, the remedies have to be decentralized. Because the kind and amount of help teachers want or are able to accept varies, delivery has to be on a basis of voluntary participation.

Thus, what seems to be called for is not a uniform and centrally planned revision of the whole school system or a set of uniform changes, but rather a set of opportunities that can be grasped by those teachers who are eager to improve. Because not all teachers will want to take advantage of such opportunities, the recommendations involve services that can be made available to motivated teachers regardless of what their immediate colleagues or the teachers in neighboring systems decide to do. If these recommendations are put into effect, many teachers will be helped, and their pupils will reap the benefits of better education in science and mathematics.

Science and Mathematics Teaching Resource Centers

The findings of the three NSF studies indicate that teachers, principals, and superintendents all attest to a need for more assistance with the local implementation of course improvement programs in science and mathematics. Such assistance could be best provided by creating a network of science and mathematics teaching resource centers throughout the nation. These centers could provide a variety of supporting services to science and mathematics teachers who want to improve their teaching. The centers could conduct inservice training programs based upon locally identified needs; provide low-cost kits of science and mathematics instructional materials to teachers from participating school systems; and provide expert resource personnel to help teachers learn to utilize new science and mathematics instructional materials and techniques.

Two successful prototype science teaching resource centers already exist in the United States. In Spencerport, New York, the Science Center for Instructional Materials and Processing (SCIMAP) is currently serving approximately 1,000 teachers and 25,000 elementary school students in the Genessee Valley. The SCIMAP assembles elementary science kits and sponsors inservice training workshops for teachers from 17 small independent school districts. The

SCIMAP operation is one of the services provided by the Board of Cooperative Educational Services of Monroe-Orleans Counties, New York. Participation in the SCIMAP science programs is voluntary; financial support is derived from the local participating school districts and the New York State Department of Education, with the state paying the larger share.

A larger Science Materials Center was established in 1970 by Lawrence Watts, Superintendent of Schools of Fairfax County, Virginia. The Fairfax resource center is operated and supported by the Fairfax County School System (the twelfth largest school system in the nation). It provides teachers with a variety of inservice training programs and with classroom kits of science teaching materials, beginning at the kindergarten level and extending through high school. At the elementary school level, it provides science kits and teacher training services for 2,400 teachers and 60,000 children.

Similar large-scale prototype support centers do not currently exist for mathematics teachers. However, because the problems of inservice training and instructional materials are similar in science and mathematics, it seems likely that a joint effort would be feasible.

One of the functions of the science and mathematics teaching resource centers would be to provide inservice training for teachers of science and mathematics in response to needs identified by local school systems. At the elementary school level, such locally based teacher training efforts are urgently needed if significant improvements are to be made in the teaching of science and mathematics.

Past efforts to institute significant improvements in science and mathematics curricula at the elementary level have often foundered, due to seemingly unmanageable problems of scale. Although it was possible to retrain a significant fraction of the nation's 15,000 high school physics teachers by holding summer institutes for several years at several universities, it has not been practical to set up institutes to train over 1 million elementary teachers. Strategies involving the training of a token number of elementary school teachers during summer institutes, with the hope that they would return to their school districts to "spread the word," were at best wishful thinking.

The three NSF studies indicate that a much greater teacher training effort will be needed if significant improvements in the teaching of elementary school science and mathematics are to be achieved. The large number of elementary school teachers who must be reached points to the need for developing locally-based institutions which could focus on this task. The proposed science and mathematics teaching resource centers could assess local needs by arranging periodic meetings with key teachers, principals, and curriculum supervisors; organize meetings of parents and teachers to discuss recent developments in the teaching of science and mathematics; provide inservice workshops on science and mathematics instructional programs and methods; enlist the help of experts to speak on topics of special interest to teachers; and arrange for staff members to visit local schools periodically to ensure close communications with schools served by the centers.

A second important function of the proposed science and mathematics teaching resource centers would be to provide low-cost kits of science and mathematics materials to teachers from participating school systems. The need for this service is especially great at the elementary school level, since most elementary schools are poorly equipped to teach science and mathematics.

It is generally agreed that science and mathematics at the elementary school level are best taught through the utilization of concrete "hands-on" experiences to develop key concepts (Hausman, 1976, p. 13; National Advisory Committee on Mathematical Education, 1975, p. 18). However, the logistics of supplying "hands-on" instructional materials to elementary school classrooms on a large scale has presented a serious obstacle to the implementation of activity-centered programs in both science and mathematics. Most school systems have not been able to develop effective mechanisms to supply instructional materials other than textbooks to elementary school classrooms. The problem has been one of scale, and also of costs. Even though the developers of the elementary level course content improvement programs usually attempted to make use of materials that would be relatively inexpensive to purchase, the marketing costs associated with the commercial production of elementary science and mathematics kits has raised the price to a prohibitive level for many school systems.

Another obstacle has been the problem of maintaining kits of instructional materials in a ready-to-teach condition after their initial purchase. Because significant amounts of expendable materials are frequently used in many of the new programs, some provision must be made to refurbish the kits each term; both to replace the expendable items and to inventory, clean, and repair non-expendable items.

The two existing science resource centers in New York and Virginia have demonstrated a practical solution to these problems. Personnel at these centers manufacture most of the science apparatus used in the elementary schools. These pieces of science apparatus, as well as packages of expendable materials, are assembled into kits that are loaned to teachers at participating schools. Considerable cost savings result from employing high school students to carry out many of the manufacturing operations necessary to assemble simple elementary science and mathematics apparatus, such as microscopes, balances, circuit boards, and trundle wheels. Additional savings are made by purchasing supplies in bulk, directly from manufacturers, and by reprocessing kits of instructional materials after each use so that they can be used by several elementary school classes each year.

Even when overhead and administrative costs are included, the science kits produced by these centers cost substantially less than those available from commercial suppliers. For example, a "Small Things" microscopy kit for a class of 32 students cost the Fairfax Science Materials Center $68 to prepare, compared with $202 for the least expensive commercial version. A large part of this saving resulted from the use of a simple elementary microscope manufactured by the Fairfax Center at a cost of 52 cents. (Seven thousand of these simple microscopes were manufactured by high school students during two summer vacations.) The least expensive comparable microscope available from commercial suppliers would have cost over four dollars. In total, the first 4,000 science kits produced by the Fairfax Science Materials Center cost the school system $211,000 instead of the $420,000 they would have cost commercially.

An added benefit can accrue by linking the provision of instructional materials support to the inservice training provided by a science and mathematics teaching resource center. Although past experience suggests that inservice training programs are most effective if teacher participation is voluntary, it is feasible to limit the availability of some kits of instructional materials to teachers who have attended an inservice training workshop designed to acquaint them with the effective use of the materials in the kit. Such an arrangement can help motivate teachers to become involved in inservice training programs who would not otherwise respond to appeals to upgrade their teaching skills. In addition, teachers often adopt a more serious attitude toward the utilization of new instructional materials if they must make an effort to qualify to receive them.

Although most essential for the elementary school level, similar teacher training and materials-support services would also be of considerable assistance to junior high school science and mathematics teachers. After the elementary school teachers, junior high school teachers comprise the group which is most numerous and least adequately prepared to teach science and mathematics.

The science and mathematics teaching resource centers could also help improve the quality of teaching at the secondary level, both by working within the constraints of existing curricula and by providing opportunities to acquaint local decision-makers and teachers with the options available for improving the curriculum. The resource centers would provide an ideal site for the introduction, adaptation, and dissemination of supplementary science and mathematics teaching materials. It might also be possible for the resource center to collaborate with university science faculties to sponsor summer institutes for science and mathematics teachers that would be closely tied to the needs and interests of local school systems.

Initially, a limited number of prototype centers might be started in locations where the essential local cooperation and support could most readily be found. It might be possible to attach some such centers to existing institutions, such as science and technology centers or universities. However, because some teacher-support institutions established in the past have become bogged down in bureaucracy and enmeshed in struggles over control, it will be important to plan the science and mathematics teaching resource centers so as to lessen the probability of such problems ensuing.

Due to declining enrollments, school systems in many parts of the country have space in school buildings that is no longer needed for classroom instruction. It might be possible to locate some science and mathematics teaching resource centers in such unused space. However, it is important that a resource center be independent of day-to-day school system management concerns, so that it can concentrate entirely on serving the teacher-support purposes for which it is being established. Ideally, a science and mathematics teaching resource center should be a quasi-independent, cooperative enterprise, governed by a board with representation from local participating school systems, and the local university and industrial scientific research community.

In areas with many small school systems, a science and mathematics teaching resource center might be operated in conjunction with the other services sometimes offered by an "intermediate school district," such as the Boards of Cooperative Educational Services that exist in New York State and the SCIMAP center in Spencerport, New York. Eventually, it would be advantageous for groups of resource centers to be loosely associated into regional networks which would allow them to share capabilities and to undertake collaborative efforts.

The findings of the three NSF studies suggest that the proposed science and mathematics teaching resource centers would be enthusiastically supported by teachers, principals, and school system superintendents. Each new center would create a focus for the professional development of teachers; establish a mechanism by which teachers could have a voice in curriculum and materials design; and provide them with innovative instructional materials and moral support.

Recommendation 1: We recommend the establishment of a number of science and mathematics teaching resource centers, each to serve a large school system or a group of neighboring smaller systems. Each teaching resource center would offer some or all of the following services: (1) inservice training programs related to the science and mathematics courses being taught or to be introduced in the school systems involved; (2) construction, maintenance, repair, and distribution of kits of materials required to teach those courses; (3) expert advice to teachers to help them learn to use new science and mathematics instructional materials and techniques, and to help them with their individual teaching problems.

This recommendation is addressed to individual school systems and clusters of neighboring systems, since such a resource center will be unlikely to succeed unless the local community wants it to succeed. Money, of course, is also needed. The resource centers in Genessee Valley, New York and Fairfax County, Virginia operate their science materials support programs for elementary schools at a yearly cost of four to six dollars per student, depending upon the grade level and the number of new science units that are introduced in a given year. This cost represents less than one-half percent of the total annual per pupil operating cost. Nevertheless, for 25,000 pupils an annual outlay of $100,000 to $150,000 would be required. Most of this cost should come from local school budgets, and we hope enough communities will develop teaching resource centers to give the idea a thorough testing under a variety of community and organizational patterns.

However, federal assistance to help with the initial costs of establishing and outfitting resource centers will be needed to encourage a substantially larger number of school systems to establish such facilities. Such centers should also be eligible for federal support for special programs, such as institutes or other special inservice teacher training programs. Continuing operating costs, however, should come from local resources and should be considered as a part of the normal cost of operating the school system.

New Courses and Learning Materials

The continued advance of human understanding on the frontiers of science requires continued revision and development of the science curriculum. The yield from research is not new "information" to be packed into young heads; it is, rather, changes in understanding. Better understanding sometimes requires not a new chapter in a textbook, but new textbooks and new ways of teaching. That task calls for the continued engagement of university scientists; through their collaboration with teachers, the linkage of primary source to the classroom can be most directly made.

A continuing program of improvement is also desirable in order to do better what we tried to do before, but in a first effort did not know how to do very well. Funding agencies need to pay special attention to the following needs:

1. The new math did not work out satisfactorily in elementary schools, but the current reemphasis on building skills in the four basic operations of arithmetic is not satisfactory either. Most elementary school children not only continue to learn primarily computational arithmetic, they continue to be taught by rote with the same lack of emphasis on logical thinking that has already produced large numbers of adult mathophobes.

The NSF case studies reported little evidence of the use of hands-on materials and found that fun and excitement were absent from almost all elementary mathematics classes. Although it is now generally accepted that firmer mathematical foundations are laid if children's numerical thinking is closely related to concrete perceptual experiences, elementary mathematics programs with such an emphasis are not common in elementary schools in the United States.

Clearly, a renewed effort to improve the teaching of elementary school mathematics is a high priority need. However, in initiating new projects, great care needs to be taken to learn from the mistakes of the past, so as to develop elementary mathematics materials that can be readily understood by teachers and parents as well as students.

2. Well-intended efforts to make education "relevant" by developing totally new multi-disciplinary or problem-centered courses have not been very successful due to the reluctance of schools and school systems to make radical alterations in the core curriculum. The NSF statistical survey found that, at the junior high school level (grades 7-9), four fairly traditional fields accounted for 86 percent of the science classes— general science, earth science, life science, and physical science. Similarly, general mathematics and algebra accounted for 87 percent of the junior high mathematics classes. In grades 10 through 12, biology, chemistry, and physics comprised 74 percent of the science classes, and algebra and geometry more than two-thirds of all mathematics classes. (See Tables 5 and 7.) Although these are the science and mathematics courses most commonly taken by secondary school students during the past decade, a disproportionately small percentage of the financial support has been allocated for their improvement. In the future, greater relative emphasis should be given to improving the courses that are taken by the largest numbers of students.

3. More attention needs to be focused on the development of science and mathematics materials appropriate to the needs of the average student, as distinguished from those students who are preparing for careers in science. In the past, it has been difficult for some course developers to appreciate the fact that not all students are interested in science for its own sake. Some courses have emphasized topics and activities that were of marginal interest to the average student.

Although it is not proposed that developers cease trying to involve students in the intrinsic delights of the pursuit of scientific knowledge, in the future an effort should be made to develop some course materials that have greater appeal to students who are not intensely interested in science.

The problem is particularly acute at the junior and senior high school levels, where there is a current need for a junior high school applied physical science course, an activity-centered earth science course appropriate to the abilities and interests of the average ninth grader, and a general education chemistry course that is less mathematical than CHEM Study or CBA chemistry.

The second and third goals of education stated on page 41 are knowledge for personal satisfaction and benefit, and knowledge for good citizenship and intelligent dealing with social issues that have a technical content. Courses aimed toward these goals are often more difficult to develop than are courses directed primarily toward knowledge as an end in itself, and many scientists are not as comfortable in trying to develop or teach them. In planning such courses, delicate steering is necessary to avoid the levels of rigor and scientific sophistication that scare some students away, and at the same time to avoid the mushiness of courses that are about but not of science, or that treat only the social aspects of a topic without giving students a better understanding of the underlying processes and principles. Developing courses to meet the second and third goals is not easy, but we think the effort is very much worth continuing.

4. There is a continuing need for the development of supplemental materials for the teaching of science and mathematics at all levels of the curriculum. Such supplemental materials can provide a focus for efforts to improve teaching, draw the attention of teachers to new ideas and teaching techniques, and serve as vehicles to add more timely and exciting activities to existing courses.

A need also exists to explore alternative mechanisms for distributing low-cost supplementary resource materials for teachers, such as resource guides, learning games, duplicator and transparency masters, and booklets for students on topics of special interest. Because supplementary materials for teachers comprise a relatively small market as compared to textbooks, their production is often not economically attractive to commercial publishers. Several branches of the federal government, including the Department of Energy and the U.S. Geological Survey, are already publishing resource materials for teachers in specialized fields. Consideration should be given to the utilization of this mechanism for the dissemination of some of the supplementary materials produced with National Science Foundation support. If such materials were to be placed immediately in the public domain, even wider distribution could be accomplished through local reprintings at regional science and mathematics resource centers.

Major curriculum development requires public funding for the familiar reason that the profit margins of textbook publishing do not generate the necessary capital. History shows that the inertia of the country's vast, pluralistic, independent, locally controlled school system, taken together with the high risk and intense competition in educational publishing, has tended to inhibit innovation and to promote uniformity at a safely mediocre level in the quality and content of textbooks and other materials sold by the textbook industry to the schools. Although many publishers were initially worried about "government interference," the responsible leadership of the industry came to welcome the curriculum-reform movement and to conclude that they, as well as the schools, had benefitted from it (BCMA Associates, 1975).

The NSF-supported curriculum-reform enterprises not only supplied fresh materials directly to the publishers that took over the distribution of their product but also made market breakthroughs that were sufficiently successful to stimulate competing publishers to update the content and enhance the appeal of their offerings.

This successful model of curriculum development needs to be revived and continued. The earlier effort was successful, in part, because the shock of Russian achievement in space motivated many able and prominent scientists to devote much attention to improving precollege instuction. There is now no single motivating factor comparable to Sputnik. But there is another kind of motivation to reinforce a sense of public duty: many scientists are greatly dissatisfied with the education of their own children.

Recommendation 2: We recommend continuation and increased support for the NSF programs of funding the design, experimental testing, and revision of new courses or curricula in science and mathematics and their associated teaching and learning materials.

The cost of this recommendation will be of the order of $15 to $20 million a year, and should be provided by the federal government. During the 1960s, 77 elementary and secondary school curriculum projects cost a total of $93.8 million, or an average of $1.22 million each (National Science Foundation, 1970). They varied substantially in size and scope; some of the larger projects cost about $5 million each. If emphasis is placed on the core subjects that are taken by the largest numbers of students, if each of these courses is revised every five to ten years, and if there are always two or three alternative programs for each subject, one can estimate that some six or eight new projects would be started each year. At the average cost of the 1960s, corrected for inflation, we arrive at a figure in the $15 to $20 million a year range.

Institutes for Teachers

The new courses developed under NSF auspices are not as widely used as they were a few years ago (Weiss, 1978), and the learning techniques that characterized many of those courses—the inquiry approach, hands-on student experimentation, and student-initiated discussion—are not in common use in most schools (Stake and Easley, 1978).

There are probably several reasons for this situation. Certainly part of the problem is due to the fact that only short-term teacher training efforts were made to solve long-term problems. Several studies have indicated that the NSF Institutes held prior to 1970 were generally successful; teachers who had attended such institutes were more likely than other teachers to be using curriculum materials developed with NSF support, to be emphasizing laboratory activities, and to be stressing a pupil-centered approach (Schlessinger, Howe, *et al*, 1973, p. 149). Nevertheless, in Fiscal Year 1971, NSF negotiations with the Office of Management and Budget resulted in a reduction of over one-third in funds for teacher-training institutes (from 33.1 million dollars to 20.1 million dollars). In explaining this change in priorities in 1971, Dr. William McElroy, the new NSF Director, stated:

> *Up to now we have put roughly $460 million into the summer institutes for high school teachers and we think we have reached the maximum benefit from this approach. We think it is time to turn around and reexamine our whole approach . . . The major cutback is in summer institutes for high school teachers . . . 40 percent of our high school teachers have now participated in one or more of these. Unfortunately, we don't have, but hope to know by the end of the year, how much further we can really go in reaching the football coach who is assigned to teach biology at the high school level (Crane, 1976, pp. 145-146).*

As it turned out, the issue was not so much how to reach the "football coach who is assigned to teach biology" as it was to give the new teachers who continued to enter the schools an understanding of the specific content, rationale, and techniques required to teach the improved core curriculum courses developed during the previous fifteen years.

Each year, the schools have a significant turnover of science and mathematics teachers. In 1971, the average teaching experience of secondary school science teachers was between 10 and 11 years (Schlessinger, *et al*, 1973, p. 103). In recent years, this figure has increased slightly; in 1977 the NSF statistical survey found an average of 11.5 years of experience for mathematics, science, and social studies teachers, with no great differences among the three subject areas (Weiss, 1978, p. 137). Many of the 40 percent of the teachers who had attended NSF institutes prior to 1970 are no longer teaching.

Although declining school enrollments have now slowed the hiring of new teachers, declining enrollments have created new problems. When lay offs are necessary, younger teachers with little seniority are the first to be terminated; they are often replaced by teachers with more seniority who have been transferred from other disciplines. In 1977, 13 percent of the secondary school science teachers in the nation were teaching courses they did not feel adequately qualified to teach (Weiss, 1978, p. 144).

For example, it is not at all unusual to find a former chemistry or biology teacher with no academic background in earth science assigned to teach that course. In such situations, teachers often abandon the more rigorous course materials in favor of alternative texts that stress reading about science, and place fewer demands upon the teacher. The classrooms of these teachers are generally distinguished by a lack of emphasis on laboratory work and a preoccupation with answering the questions at the end of each chapter.

Unfortunately, the adequate opportunities have not been provided during the 1970s for retraining teachers who have been transferred to new fields. The 1971 reduction in funds for teacher institutes described by Dr. McElroy was followed by further reductions, and in 1975 all funding for NSF teacher training programs was suspended. In 1976, Congress restored $4 million for teacher institutes but restricted its use to institutes that are disciplinary in nature and not integrated with course development efforts. These are institutes of the original kind, those intended to help teachers learn more chemistry, more mathematics, or more of some other subject they teach. Although there has been some dissatisfaction with the extent to which these institutes actually increased the scientific knowledge of teachers attending them, there has been general approval of the objective.

Much more controversial has been a second type of institute. As new courses and materials were prepared by some of the curriculum projects supported by NSF, it seemed desirable to give teachers of those courses special training not only in the subject matter but also in methods of handling the laboratory and other special materials used in the new courses, and in how to use the discovery or inquiry method of teaching that some of these courses emphasized.

The second objective has been both confused and criticized. The purpose has sometimes been described as stimulating the adoption of new curricular materials that had been developed with NSF support, and when so described has been justified in increasing the effectiveness of the courses developed under the NSF Course Content Improvement Program. At other times, however, the same effort has been criticized as improperly interfering with course selection decisions that should be made at the local level. These course-specific institutes have also been charged with being unfairly competitive with private textbook publishers who do not have funds to support teacher training institutes.

Although both of these issues have been overemphasized in recent years by some members of Congress, there have been few complaints from publishers or school district officials. A 1975 report on the elementary and high school publishing industry indicates that, although the publishing industry was apprehensive twenty years ago when the NSF Course Content Improvement Program was initiated, most publishers now appreciate the need for course-specific institutes. The report explains:

> *[Publishers] may not be equal to the challenge of new curriculum materials with their new approaches to teaching and learning and with content frequently not included in the teacher's undergraduate and graduate curriculum. The publishers' efforts to expand implementation beyond their present efforts is limited by the money available in school budgets. Many publishers are convinced that the programs they develop with a heavy investment of their own funds, as well as the programs developed by Study Groups and Councils, do not always live up to expectations because of the cost limit imposed on implementation (BCMA Associates, 1975, p. 21).*

Moreover, the spectre of interference in local curriculum decisions is dispelled by the endorsement of NSF activities by many school superintendents. The NSF statistical survey found 58 percent of the superintendents agreeing that federal support has improved the quality of curriculum alternatives available to schools, 66 percent believing continued federal support for curriculum development to be necessary, and 77 percent believing that NSF should continue to help teachers learn to implement NSF-funded curricula (Weiss, 1978, p. 76).

Several changes in NSF policy had the effect of depriving many teachers of contact with the individuals who were most knowledgeable and most committed to the successful utilization of the new materials in the core areas of science. These changes included NSF's reluctance to fund teacher training efforts by the groups responsible for developing the new materials; termination of some of the projects in the core areas before their fruition; and a switch in emphasis from the core subjects to interdisciplinary approaches and social studies. During the period when the largest numbers of teachers finally began to use the core curriculum materials developed with NSF support, most of the curriculum project personnel were dispersed, and could no longer respond to the problems encountered by teachers. This discontinuity also prevented project personnel from becoming significantly involved with the very real problems of large-scale course implementation; such experience could have provided the basis for substantive improvements in later revisions of the course materials.

Although there can be no substitute for subject-area competence, the NSF statistical survey revealed that large numbers of teachers indicated a need for additional assistance in obtaining information about new instructional materials (43 percent), learning new teaching methods (43 percent), implementing the discovery/inquiry approach (36 percent), and using manipulative materials (33 percent) (Weiss, 1978, p. 147). The discipline-centered institutes that are now authorized may be able to meet some of these needs in addition to increasing teachers' knowledge of the discipline involved. But past experience has shown that there is no such thing as a "teacher-proof" curriculum. Unless adequate teacher training programs are provided when new courses are introduced, very little change occurs in the classroom save the substitution of one textbook for another.

Most of the major curriculum development groups have stressed that the approach used by teachers in the classroom is as important as the new course materials. Some projects have stressed that the success of their materials in the classroom is critically dependent upon the adoption of a new role by the teacher. Teaching science or mathematics with an emphasis on the quality of children's thinking is an alien experience for many teachers, and is not an easy task for anyone. Teachers who are not convinced of the need to change their approaches to teaching can and do sabotage even the best of the new programs.

The NSF case studies suggest that considerable attention needs to be given to the development of strategies to help teachers cope successfully with the practical problems created by the introduction of new teaching approaches and materials into their classrooms. Substantive and long-term teacher training efforts are needed, both to update teachers' understanding of science and to address the specific problems and challenges that the new courses generate, such as the use of the inquiry approach, the development of questioning techniques that focus on the quality of a student's thinking, the management and use of manipulative materials, the orchestration of a multi-media approach, the evaluation of student achievement, and the maintenance of discipline in an activity-centered classroom.

Rarely are these skills adequately mastered in the preservice education of teachers, partly because teachers usually do not know which courses they will be teaching until they are hired, and partly because theoretical discussions of pedogogy do not seem to have much impact on teachers before they have grappled with the realities of managing their own classrooms. The alternative is more effective inservice training programs, but local school systems do not have the capabilities, resources, or will to assume responsibilities for the inservice training of science and mathematics teachers, particularly at the secondary level. It is therefore important that the National Science Foundation resume support for institutes that can be course-specific, as well as for those that are primarily disciplinary in nature.

The charge of undue interference in local curriculum selection decisions need not arise, for NSF funding of institutes with the original emphasis on the upgrading of individual teachers would allow NSF to remain at arm's length from the adoption of specific programs by specific school systems. After a school system has decided to introduce a particular new program, special training for the teachers is essential regardless of whether development of the new program has been supported with NSF funds.

In addition to inservice training programs for teachers, more efforts should be made to develop summer institutes for elementary and secondary principals, focused on new approaches to the teaching of science and mathematics. Besides making principals more effective, such efforts might also enlist their support in recruiting reluctant teachers to participate in inservice training institutes.

Recommendation 3: We recommend support of an NSF program of institutes for teachers, both to increase their knowledge of subject matter and to improve their skill in teaching the new courses that will be developed in the future, whether the development of these courses is funded by public or private sources.

Although there has been much testimony to the value of the NSF institutes, it must be acknowledged that the leaders of some of the institutes were disappointed that they were not more effective. In planning for future institutes, attention should be given to overcoming the deficiencies reported in some of the past ones.

At peak level during the latter half of the 1960s, NSF was expending close to $40 million a year to support institutes attended by about 40,000 teachers a year. Nearly 90 percent of the institutes were for high school teachers, and the major cost was for stipends for the teachers who attended summer or year-long institutes. The part-time institutes attended by inservice teachers were considerably less expensive. For the future there is no "right" number of institutes; the number will be determined by the normal political processes of balancing competing needs and opportunities, but we believe the program should have permanent, continuing status.

Non-Traditional Educational Opportunities

Much learning goes on outside of schools and school lessons. The Panel had extensive discussions on only one of the non-traditional educational agencies—the science and technology centers that now constitute the most rapidly growing segment of the museum world. But two others should be mentioned, for although the Panel did not consider them in detail they will have to be given careful attention in future efforts to improve science education.

One has resulted from recent revolutionary changes in electronic circuitry. The hand-held calculator is used by many thousands of students and teachers, to solve a variety of quantitative problems. Computers of increasing power and decreasing cost have added a new dimension to instruction in a range of subjects. Computer-aided instruction has not fulfilled all the hopes of its advocates, but surely is not yet to be dismissed. When and how these powerful tools can most effectively be used in education is a topic of much importance in future studies of science education.

The other is television, which has clearly become an enormously potent force in American society. Most children watch and are influenced by it, and several studies have suggested that by the time they graduate from high school, many students have spent more time watching television than attending school—20,000 hours and more.

The Panel noted that in the past, TV science programs have not been popular with children (Holden, 1978) and that even the best programs have not been totally successful, particularly in involving the child actively, instead of as a passive spectator. Nevertheless, a major challenge and opportunity lies in using television, perhaps in unconventional ways, as a tool to improve science literacy. The Children's Television Workshop science series now being developed has attractive possibilities; the Panel would hope other innovative approaches can be found.

It is possible that new and cheaper technology might help in making children more active participants. For instance, it is likely that video discs will soon be available in classrooms so that video materials can be consulted readily and without help from teachers, just as books can now be used. Similarly, cheap hand-held video cameras and recording equipment could allow children to video-record their own science programs, the goal being not necessarily the finished product but rather involvement in the process of program preparation.

Television and the computer have drastically changed most people's lives in the past 25 years. However, the right strategy for their use in education, particularly in science education which depends heavily on active individual discovery and conceptual development, is not evident. Certainly much harm can be done by the misapplication of inappropriate technologies, and the glamour of sophisticated technologies often casts them in the role of a solution in search of a problem. The Panel would hope that in the future the educational value of these technologies will be assessed objectively, giving full consideration to both costs and benefits, so that their most appropriate uses in children's science and mathematics education can be identified.

SCIENCE AND TECHNOLOGY CENTERS

Many a visitor has come away from a museum, a planetarium, a zoo, an aquarium, or a science and technology center with a new interest, or an enhanced understanding of some scientific process or phenomenon. These non-formal educational institutions differ in kind, style, and effectiveness, but in communities that are fortunate enough to have them they can be valuable resources to children and adults who want to know more about science and technology.

Their permanent and traveling exhibits and their specialized collections and facilities provide opportunities for experiences that are practically never available in schools. One can watch a polar bear, view science films, get a close-up view of a live octopus, sit in a space capsule, or examine artifacts from early civilizations and other cultures. And in a science and technology center—much more than in the typical museum or zoo—one can also manipulate, try out, and experiment with equipment specifically designed to facilitate learning through experience. As compared with school, the learning is less systematic, deliberately less formal, and more dependent on individual initiative and interest. At the same time, the experience can enrich the classroom fare, allow one to go more deeply into an interesting topic, and bring a topic to life through close study and manipulation of specific examples.

These benefits are available to those that seek them. Yet there has been surprisingly little research on what and how visitors to museums, zoos, and science and technology centers really learn. It seems clear that some visitors learn much, and attendance records and the number of repeat visits give evidence that many people value these institutions. The science and technology centers are especially popular; a 1974 survey by the National Endowment for the Arts found 38 percent of all museum visits to be to science and technology centers, as compared with 24 percent to history museums and 14 percent to art museums. Science centers had 36.5 million visitors in 1975 (Kimche, 1977; Roark, 1979).

Because of their popularity and flexibility, science centers can be very important contributors to increased science literacy of the American public. How their programs and exhibits can best contribute to this end is an area of educational research that merits much more effort than it has received in the past.

In addition to their classic, museum-like function of presenting interesting and informative exhibits, many of these institutions offer other educational opportunities. Examples include:

> Special lecture-demonstrations, given to school classes brought to the center for that purpose, or taken to the school by the center staff, together with a van load of demonstration equipment.
>
> Organized classes, a few hours a day for preschool children; and short courses on photography, magnetism, geology, computer programming, and many other topics, taught at levels appropriate for designated age groups.
>
> Guided tours, work on projects that have educational value, a home and meeting place for amateur science clubs, and a variety of other activities, some for particular age groups and some designed to attract whole families.
>
> Internships for elementary or high school teachers who want to learn more about science education and how to make use of a variety of kinds of equipment, or for prospective teachers during their preservice education.

Typically, the people who take advantage of any of these opportunities constitute a voluntary, self-selected group; people visit museums and science centers because they want to. Thus the students who make most use of these out-of-school opportunities are likely to be those who are most interested in science, for there they can pursue their interests to greater depth, in new directions, and at their own pace—all more readily than is usually possible in the more structured atmosphere of the school.

This aspect is an asset that should be preserved, for under current priorities the abler and more highly motivated students are now often given less attention in school than their abilities and their potential contributions to society would warrant. At a science center, they can pursue favorite topics in more depth, work on science projects, and get expert advice more readily than in most schools.

At the same time, because these centers are located in cities, they can also provide inner-city youngsters with better opportunities to learn what the natural world is like than can be offered by the fenced-in blacktop surrounding a city school building. Some centers have already started special programs for this purpose, such as the events sponsored by the Oakland Museum to involve local community members and the "explainer" student intern program of the San Francisco Exploratorium. Science centers can plan quite significant roles in providing alternative educational experiences for talented students from inner-city schools who do not have sufficient opportunities in school to pursue scientific interests. This concept will be discussed in more detail later, in the section entitled "The Needs of Special Groups."

In some communities, the local science and technology center may be the best organizational base for a science and mathematics teaching resource center of the type described earlier. A science center provides a degree of independence from the school system itself. The center's staff may include experienced and successful teachers and also practicing scientists interested in improving science education. And it may already have a variety of useful supporting services, such as shops, technicians, and graphic arts facilities. The decision is obviously a local and individual one, for many communities do not have a science and technology center. But in communities in which they do exist, their educational usefulness could sometimes be increased by enabling them to assume the additional role of a teaching resource center.

In a number of communities, the educational value of science and technology centers is already so widely recognized that they are being pressed to do more than can be supported by their over-strained budgets. All of their functions require money, and admission charges are never sufficient to meet expenses. Gifts from private sources or subsidies from public ones are essential. Contributions from business and industry, grants for special projects from private foundations and federal agencies with scientific and technical interests, and the new but still small sustaining grants from the federal Institute for Museum Services are all needed, and all helpful.

In some communities, the school systems of the region have found the local science and technology center to be so valuable that they regularly provide some support from school budgets. This is a relationship to be encouraged, for it gives both sides an on-going interest in developing the most educationally useful methods of collaboration between the formal school system and these non-school allies in improving science education.

Recommendation 4: We recommend the development of additional science and technology centers of the kind that now exist in a number of cities. Furthermore, we recommend the strengthening of cooperative arrangements between these centers and nearby school systems to increase the extent to which the centers provide planned supplementation of the programs of the associated schools, and to increase their general value to children and adults who wish to learn more about science.

This recommendation does not call for action by the federal government. A number of cities have found means to develop science and technology centers; their number is growing; we hope it will continue to grow. But we are not recommending their establishment anywhere except where there is sufficient local interest and local financial support to get one started.

The Needs of Special Groups

Minority group members and women are seriously under-represented in science and engineering. In 1974, minorities constituted almost 11 percent of the employed labor force, but occupied only about 5 percent of all jobs in science and engineering. Women, who made up almost 40 percent of the work force, comprised only 6 percent of the employed scientists and engineers (NSF, 1977, p. 7).

These disparities are so great as to show clearly the need for positive efforts to increase the opportunities for women and for members of minority groups. But citing the disparities does not mean that our objective is exact statistical parity of all groups in all occupational fields. Indeed the attainment of precise statistical parity in all fields would no doubt require the illegal use of race and sex as criteria for selection. In any event, the goal should not be statistical, but individual: any child who has the necessary interest and ability should not be denied access because of race or sex to a career in any field of science or any of the professions based on science.

Among the four generally identified minority groups, persons of Asian origin are statistically over-represented in science and engineering, and therefore do not need special attention in the context of this report. The other three—American Indians and Alaskan Natives, Blacks, and Hispanics—are all under-represented. Of these three groups, Blacks are most numerous, have been most studied, and will most often be used as the illustrative minority group in the following discussion. In general, however, the special needs of Blacks are matched by similar needs of the other two minority groups, and also by those economically disadvantaged children in general.

Blacks constituted 15 percent of the 18-21 age group in 1974 and 10.7 percent of the total undergraduate population. But Blacks constitute only 6.9 percent of undergraduates majoring in the biological sciences, 5.9 percent of those majoring in engineering, and 4.6 percent of the physical science major (Office of Civil Rights, 1977).

At the graduate school level, the numbers of minorities receiving doctorates in scientific disciplines are even lower. Blacks, Hispanics, and Native Americans account for almost 20 percent of the population, but in 1977 constituted less than 4 percent of the Ph.D. recipients in all science and engineering fields, including the social sciences. Women received 18 percent of the doctoral degrees in science and engineering in 1977 (National Research Council, 1978).

The situation means that as a nation we are not utilizing effectively many gifted young people, although technological innovation is widely recognized as a need focal to our economic health. A large fraction of the nation's corporate executives and more than half of the federal decision-makers (GS-18 and above) come from science and engineering backgrounds. It is unfortunate that more women and minorities are not receiving the scientific education that would improve their opportunities for upward mobility.

As children approach adolescence, the availability of role models becomes an important factor in their selection of future careers. Studies have shown that, although parents are listed by adolescents as the individuals most responsible for their career choices, associations with other adults holding specific occupations are second in importance (Pallone, Hurley, and Rickard, 1973). There is a need, therefore, to provide more women and minority group role models, if we are to encourge more adolescent girls and minority group students to consider careers in science.

Ways should be explored to increase the number of such role models on the science and mathematics faculties of secondary schools. However, minority group students and girls need contact with role models from scientific careers other than secondary school science or mathematics teaching. It is here that industry and university science and engineering departments can provide an important service by lending scientific personnel to work with minority youth and girls.

The Minorities in Engineering programs initiated throughout the country beginning in 1972 provide many examples of cooperative efforts involving local school systems, industries, and universities (Committee on Minorities in Engineering, 1977). With support from a number of industrial corporations and their foundations, these programs have focused on establishing local organizations that encourage interactions among secondary school personnel, college faculty members, industrial personnel, and community groups.

However, much remains to be done, not only in engineering but in other scientific fields. Until it is possible to improve significantly the quality of mathematics and science education for all disadvantaged children, particularly in inner-city schools, there is a need to develop an approach that will identify gifted but economically disadvantaged students early in elementary and junior high school and follow them through high school and college, so as to provide them with the support necessary to increase their opportunities for learning and their chances of success. There is much that could be done to help such students cross the academic hurdles in their path, such as the establishment of special schools or schools-within-a-school, the provision of summer enrichment camps in science and mathematics, the arrangement of part-time student apprenticeships with professional scientists and engineers, and the provision of special career-planning assistance for students and their parents.

If larger numbers of women and minority group members are to have careers in science and engineering, larger numbers of students must be put into good science and mathematics courses, enrolled in the college-preparatory programs in high school, and given the education that will qualify them for admission to scientific and technical programs in college. Effective actions of this kind should be the conscious and measurable objectives of programs to increase interest and motivation.

Even if many special efforts are made, the task will take decades. Success will require a national commitment lasting into the next century. The fact that the task cannot be accomplished quickly should not deter us from continuing on what must necessarily be a long-term effort.

Recommendation 5: In order to give women and members of racial or ethnic minority groups greater opportunity to become interested in and to prepare for careers in scientific and technical occupations, we recommend that scientists and engineers work with their local school systems to provide special lectures and classes; tours of local scientific, engineering, and technical facilities; opportunities to meet with appropriate role models; and other experiences intended to increase their motivation and to overcome their disadvantages in securing the education necessary for scientific and technical careers. In addition, we recommend that efforts be made to identify gifted but economically disadvantaged students early in their schooling, so as to ensure that they will be afforded adequate opportunities to prepare themselves for admission to scientific and technical programs in college.

Accomplishment of these objectives will require widespread, decentralized, continuing effort on the part of many organizations and individuals. This recommendation is equally broadly aimed.

Accountability and the Use of Tests

The phrase "back to the basics" summarizes the most widely publicized recent campaign in education. Three quarters of the States of the Union have adopted some form of minimum competency legislation, legislation requiring students to pass certain tests before being promoted or allowed to graduate. Both the back to the basics movement and the minimum competency legislation are evidence of increasing public insistence that schools be held accountable for the performance of students.

The whole movement has been fueled by widespread complaints that high school graduates are not as well educated as they should be. Employers complain that new young employees with high school diplomas are illiterate. College English departments are having to shift more of their Freshman English classes to work on composition and remedial English instead of teaching literature courses (Gibson, 1978); publicity has been given to declining scores on the Scholastic Aptitude Test, and part of that decline has been related to the fact that "less thoughtful and critical reading is now being demanded and done" and "careful writing has apparently about gone out of style" in many schools (Wirtz *et al*, 1977).

So the call rises for an end to social promotion, the abolition of frills and a reduction in the number of soft courses, for greater emphasis on the basics of reading, writing, and computation, for the use of standardized tests to determine whether students have attained minimum competency, and for increased accountability on the part of the schools.

The motivation for much of this concern is highly laudable. The public should be interested in its schools. There is room for much improvement in the curriculum. Reading and writing are basic and essential skills. Schools should be accountable for the effectiveness with which they educate the nation's youth. The trouble with accountability is not with the concept, but with the method by which student performance is measured and publicly reported.

If teachers know the tests that will be used to compare their pupils, their schools, and their own performance, of course they will emphasize in their teaching the skills and knowledge that are emphasized in the tests. Nothing else could be expected. Indeed teachers would be remiss if they did not help their students acquire the information and skills on which they will be judged.

It is therefore necessary to understand the methods by which pupils are judged, and to analyze the slogan "back to the basics," for that slogan seems to have different meanings for different users. As a reassertion of the primacy of the central core subjects in contrast with a variety of "fringe" or "soft" courses, it raises a question of educational philosophy on which there is continuing argument, and to which the answer often depends upon the particular students being considered.

As insistence on mastery of the facts, methods, and skills that are essential for competent performance, learning the basics of mathematics or other subjects has the same kind of solid justification that it does in learning to play basketball, or a musical instrument. Initially, reading, writing, and arithmetic are skill subjects. After the rudiments have been learned, they become much more than that; but for a beginning pupil much practice is required to master the basic skills. Because those skills are essential for other school subjects and for effective management of many aspects of adult life, the public is right in wanting to hold schools accountable for the ability of their students to read, write, and calculate with reasonable competency.

Reasonable competency may be all that can be expected of some students, but for others that level is not enough, particularly in the higher grades and especially for the more competent students. Thus loss results when back to the basics sets limits on what is to be learned, as it does when (1) some subjects, such as science, are excluded from the definition of basic education which is used to allocate state funds to local schools; or (2) teachers and students are led to believe that there is no need to go beyond the level of minimum competency, as they are when promotion or graduation are determined by scores on tests of minimum competency.

It is this last interpretation, or implementation, of the back to the basics and minimum competency movements that we strongly oppose. When those movements set a low ceiling on expectations and opportunities, many of the children and society are deprived. Ralph Tyler provides an example of how the low ceiling of a minimum competency requirement affects schools:

"In Florida, the National Education Association panel (which I chaired) heard criticisms that the eleventh grade testing program was resulting in an overemphasis in many high schools on elementary reading, arithmetic, and specific test items in order to ensure that students can pass the tests. As a result, high school subjects such as science, history, literature, music, and the arts have been neglected. Some of the teachers actually believed that the law now required them to narrow the curriculum to these minimum competencies. . . . Many teachers interpreted the emphasis on basic skills to mean they must devote most of their attention to routine drill" (Tyler, 1979, pp. 29-30).

An encouraging contrast to this report is the fact that some students now seem to recognize what has been happening; a recent survey conducted by Gallup Poll and the Kettering Foundation found many students saying that elementary school standards are too low and that classes are not sufficiently challenging.

In practice, the emphasis on minimum competency has led to over-reliance on tests of those aspects of the curriculum that can be most readily expressed in simple numerical scores. This tendency is reinforced by the already wide use of objective and nationally standardized tests of aptitude and achievement, and by the desire on the part of parents, the public, and school administrators to be able to compare this year with last year, or this school with that one.

Unfortunately, this emphasis on numerical measures that are easily obtained and easy to report undermines an important part of the schools' educational function, for the tests that best satisfy the desire for ease of administration and reporting are, in the main, designed to measure the simpler and more routine aspects of education: ability to perform the four fundamental processes of arithmetic rather than understanding of mathematical principles and reasoning; remembering the names of concepts rather than understanding their meaning; ability to recognize rules and principles rather than ability to interpret and apply them; ability to recognize parts of speech rather than ability to write literate English. Yet as a report from the Council for Basic Education emphasized, "without the **thinking** elements science teaching is stripped of its greatest appeal to children," and these "more subtle and often more important objectives of education" tend to be suppressed by the rigid application of accountability measures (Hausman, 1976, pp. 3 and 10).

It is possible to improve the examinations that are used to measure minimum competency, and that should be done for they will no doubt continue to be used. But even at their best, they help establish a single standard for the granting of an educational credential, a standard that may be discouragingly high for some students and dispiritingly low for others. As stated earlier, there are important basic skills that students should be expected to learn, and it is appropriate to require demonstration of competency in reading, writing, and arithmetic computation. But measures of these skills should never constitute the sole basis for decisions concerning promotion or graduation of students or the evaluation of school curricula. Tests of these skills do not measure and do not purport to measure all that should be considered in making those decisions.

We, therefore, recommend that teachers be provided with a more desirable and flexible alternative: a large bank of carefully constructed examination items from which individual schools and individual teachers can select their own examinations (Zacharias, 1979). There should be such a bank or reservoir of test items in each subject or major area included in the curriculum: in the sciences, and also in foreign languages, social studies, the arts, and all the rest.

Each bank should cover a wide range, from the elemental and simple facts to the ideas, the concepts, the methods, and the more difficult and abstract aspects of the subject. Each item bank should include questions of several types. Some can be of familiar multiple-choice form, but other types would also be included. Essay or discussion questions are harder to score, but pedagogically more effective. In between multiple-choice and essay questions are open-ended questions that can be answered by a word, a phrase, a sentence, a computation, or a comparison. These items can be scored in a highly reliable manner; they can be phrased to require real understanding; they can be written in great variety; they serve more effectively as a basis for class discussion than do multiple-choice items; and they stand up better to public scrutiny.

Each bank should be large enough to provide very wide choice in selecting items to make up different examinations—different in order to be appropriate for the wide range of schools and pupils that exist in the United States, and different so the same school or teacher can draw many examinations from the bank.

Moreover, and most importantly, the bank should not be secret. All of the test items should be publicly available to teachers, parents, school children, or anyone who is interested. Unlike tests whose secrecy must be carefully preserved, there would be no danger in allowing students to examine the test bank. Within any field—biology for example—there would be so many different items, testing so many different aspects of biological knowledge, principle, and method that any teacher could say to a pupil: "Go to it. If you can answer the questions in the biology bank you know enough biology to earn a high grade."[2] It may be desirable to add that under most circumstances the particular items from the bank that will appear on a given examination should not be announced in advance. The whole item bank should be open, but if the particular questions on which students will be graded are known in advance, students will be tempted to concentrate too exclusively on the answers to the selected items.

Open access to the whole test bank would force the people who construct the test items to do a better job. It is difficult to write test items that assess a student's ability to think clearly, to understand principles and relationships, to express ideas in clear, concise prose. It is more difficult to write such items than to write test items that depend on memory for facts, names, or word meanings; but it is not impossible. If all of the items are open to public inspection, and if the test bank is expected to cover the whole range of curricular objectives, the test writers would have to do a better job.

If all of the items are open to inspection, they are also open to objection by experts. Scientists could challenge any that involved faulty understanding of the scientific facts or principles involved. Representatives of minority groups could challenge any that seemed unfair to their groups.

The purposes of these test banks would be to improve education and to give teachers wider latitude in measuring what their pupils have learned than is possible with standardized tests. For other purposes, tests of other types are available. Employers and college admissions officers can continue to use standardized tests to aid in making their selection decisions. Educational and vocational counselors can continue to use the tests they find of value in their work. The National Assessment of Educational Progress will no doubt continue to use tests designed for its purposes. Tests for these uses are typically the same throughout the country, and care is exercised to keep the test items secret, at least until after the test has served its purpose.

But neither national standardization nor secrecy are necessary for tests used to assess progress during the school year; to help diagnose areas of strength or weakness; to use as starting points for classroom discussion or other forms of teaching, or to determine when a student is ready to move to the next level or block of material; or is ready for promotion or graduation. For these purposes, examinations consisting of questions selected from the appropriate test bank can give each school or teacher substantial latitude in selecting items with the content and at the level that is appropriate for that particular group of students.

Recommendation 6: We recommend vigorous efforts at local levels to combat the overemphasis currently given to scores on standardized tests of achievement in comparing the performance of schools, classes, and individual pupils. Because the tests most generally used for these purposes give emphasis to the more elementary and routine abilities necessry to meet "minimum competency" requirements, they constitute only a part of the basis upon which schools and pupils should be judged. In addition, in order to make available more desirable tests with which teachers can appraise the performance of their pupils, we recommend the creation, for each major subject, of a large bank of test items of varied types and covering a wide range of skills and knowledge of the subject field. These test banks should be openly available to any teacher, school administrator, parent, child, or anyone else who is interested. Open availability of the entire bank of test items should improve the quality of test items and will give teachers latitude in selecting the test questions that match their educational objectives.

---

[2] Beginning in the 1930s, the University of Chicago faculty—with help from the University's Board of Examinations—constructed long, searching examinations that were the sole basis for grading in many courses. These examinations included some multiple-choice and other objective items, some to be answered by a word or phrase, and some that required longer answers. As soon as one of these examinations was used, copies were made available in the University Book Store for purchase by anyone interested. This system worked very satisfactorily. The faculty had to construct good examinations, ones they were willing to make public. Students had the opportunity to find out in advance what the faculty considered to be the content, scope, and appropriate examination for a course. The reasonableness of our proposal is supported by this favorable experience, but our proposal goes further in making the whole bank of items available from the start.

Much work would be involved in making up the thousands of items that would be needed for the item banks in all of the major areas of the school curriculum, and to pretest the items to determine their difficulty and uncover hidden ambiguities. Because the test items would be of quite varied types, more time would be required to score them than is necessary for tests that can be scored by machine. But offsetting these costs would be the large amount of time saved by not having to construct individual teacher-made tests and the advantage of having access to a large resource of reliable and well-tested items from which any teacher could draw examinations tailored to the particular needs and interests of a school or class.

Implementation

Successful achievement of the objectives of our recommendations will require leadership, cooperation between the scientific and educational communities, and continuing government support for private initiative.

Leadership

Most of the leadership must come from scientists and scientific organizations. The NSF studies indicate that leadership in this effort is quite unlikely to come from anywhere within the educational system. Only a small percentage of school superintendents and principals are primarily interested in science or mathematics. Teachers rate them low among available sources of help on problems in teaching science and mathematics. A maze of state and federal regulations and requirements forces them to be systems managers rather than educational leaders.

Some subject matter coordinators could serve as leaders, but the excellently qualified ones are few in number, and typically they are able to devote only about a fourth of their time to working with teachers on instructional matters.

The individuals teachers who are interested are geographically scattered. Working on curricular reform and the development of innovative teaching materials is not generally rewarded in most school systems. Some of the specialized societies, such as the National Council of Teachers of Mathematics or the National Science Teachers Association, can be very helpful. But the major national association, the National Education Association, has lost most of its former interest in educational matters as it has become an aggressive labor union.

Thus, responsibility for leadership seems to lie in the hands of scientists and scientific associations. In the 1950s and 1960s most of the scientists actively involved in the curriculum projects came from academic institutions, and that will probably be true in the future. But there is also a rich source of talent among scientists and engineers in industry, and they may be of special value as greater emphasis is given to improving science learning for all students, whether or not they are going to college or whether they are likely to follow careers in the scientific and technical fields.

From wherever they may come, scientists will have to take the initiative. Many are not satisfied with the present performance of the nation's schools, and believe that improvement is possible and necessary. They now have the choice between doing the hard work necessary to provide leadership in bringing about the desired improvements or of resigning themselves to the expectation that those improvements will not occur.

Institutional as well as individual leadership will be necessary, and the National Science Foundation is the most experienced and appears to be the most appropriate institutional leader. Other federal agencies, school systems, and private foundations should help, as they have in the past, but a leading agency is required to focus the governmental interest and support.

One of the unknowns of the legislative future is whether Congress will vote to establish a new Department of Education, and if it does so, whether it will transfer the precollege educational responsibilities of NSF to that new Department as some of the advocates of the new Department propose. The case can be argued either way. Science education is part of education and should therefore be part of the new Department. Or, science education is part of science and should remain in close alliance with other scientific activities. If a new Department of Education is established, it may develop in such a way as to make the transfer seem desirable. But for the time being, we give more weight to two reasons for retaining responsibility in the National Science Foundation. One reason is the nature of the activities to be supported. The recommendations presented above will require individual decisions as to which proposals, among a number submitted, are most meritorious and can be supported. NSF has had much more experience in the support of individual projects selected as most meritorious by the processes of peer review than has either the Office of Education or the

National Institute of Education. Indeed, a substantial part of the Office of Education responsibility has been for programs in which funds are allotted by formula instead of on a selective basis.

The other reason concerns the personnel involved. Scientists, who will have to lead the whole effort, already have well-established working relationships with NSF. Moreover, because the interests of scientists in education are often closely linked to their interests in research, strong continuing relationships with NSF are altogether likely. For these historical and organizational reasons, we believe that the NSF should continue to be the federal agency with major responsibility for supporting efforts to improve science education at the precollege level.

Cooperation

Leadership will come from scientists, but they should make greater efforts to enlist the active cooperation of the educational community than they did in the 1950s and 1960s. Specialists in education are needed and they can be of much help in getting improved programs accepted by the educational community. They can also be more directly effective in devising systems to reward teachers for using better materials and methods, and can help build into the education system the idea of a continuing effort toward improvement.

New curricular materials are generally more demanding of teachers than were the textbooks that preceded them. They call for greater understanding of subject matter, and require effective use of teaching skills that are not required by simple reading and recitation. But this is not what is emphasized in most schools of education. So far the schools of education have had relatively little involvement in the course improvement effort. Individuals, particularly specialists in science education, have been valuable members of many of the projects teams. And some of the institutes for teachers have been sponsored by schools or departments of education. But the education profession did not initiate the major efforts to improve education in science and mathematics, and the initiators of that effort have not done enough to enlist the continuing cooperation of that profession.

Now, with clear recognition that a continuing effort is needed, the leaders of that effort should seek means of involving more effectively the deans and professors of education. In the long run, it is they who will determine whether new teachers enter their first positions reasonably well grounded in their fields and able to use teaching methods that help young students learn to think and develop rational abilities. The schools of education should inculcate the attitude that curricular improvement and the development of better materials and methods will be an expected and continuing part of each teacher's professional life.

Support for Private Initiative

Twenty years ago, NSF clearly distinguished the educational responsibilities of the federal government from those of the private sector and local government. Congress had recognized the need for federal assistance to the nation's schools, and NSF was authorized to use part of its funds for that purpose. But it would not try to control; instead, it would support "the activities of competent persons and groups in the scientific and academic communities in carrying out what those communities judge to be needed and proper. The Foundation takes pains to avoid wherever possible the implication of endorsing or specifying attitudes, the nature of course content, or related items which are properly the province of the educational community. The initiative must derive from the academic community" (Quoted from 1959 budget statement, NSF, 1975, Vol. II, p. 21).

In taking this posture, NSF was honoring the long and deep tradition that educational responsibility is reserved to private institutions and to state and local government. At the same time, NSF was honoring another deeply rooted American tradition, that voluntary private action is often the most effective way to accomplish major public purposes. In supporting research, NSF had already followed this course. It was accustomed to selecting the most promising proposals from among all those submitted, but it did not try to decide what problems should be tackled next or what methods should be employed. Scientists actively engaged in research were considered to be the best judges of those matters. And so it was with improvements in education; scientists and the educational specialists and teachers who were working with them were considered to be better judges than the NSF staff members of what should be taught to precollege students and of how it should be taught.

For several reasons there has been appreciable backsliding from this position. Congress still pays tribute to the tradition of local autonomy, and in fact has reprimanded NSF when it thought some of the Foundation's implementation activities had gone too far in influencing school systems as to the curricular materials they should use. Congress itself has not tried to dictate what should be taught in the nation's schools, but it has come dangerously close in deciding some things that should **not** be taught. When some of the NSF-funded projects in the biological and social sciences encountered criticism in Congress as being value-laden or controversial, NSF was seized by anxiety. Both Congress and the General Accounting Office have warned NSF that it cannot avoid being responsible for the content and conduct of curriculum development projects, and that it should take a more active role in determining in advance what is needed in the way of educational improvement and then seek means of responding to those needs.

NSF has been immensely valuable in achieving many of the improvements in science and mathematics education of the past quarter century. Other federal agencies and some private foundations have also been involved, but NSF has clearly been the primary supporter of the whole movement. In large part its success has been due to the fact that it had the confidence of the scientific community, and it, in turn, was geared to provide financial support for the best ideas and proposals that were generated in that community. NSF was successful because it did not try to mastermind the whole effort and because it could pick and choose from among all the ideas emanating from the community of scientists and educators interested in the improvement of education.

Much experience tells us that the support of private interest and effort is often the most effective way to achieve a public purpose. But when private initiative is supported by public funds there is strong temptation for the provider of those funds to exert more and more control. Unless that temptation is resisted, the private initiative that started the whole effort is weakened, and is likely to be squeezed out. The fact that this tendency is wrong in principle and usually inefficient in practice is likely to be forgotten by a bureaucracy that is overly responsive to criticism. Nothing useful in education can expect universal approval. The response to criticisms must not be the typical bureaucratic remedy of stronger central control.

In looking toward the implementation of the recommendations made above, the tendency toward centralization and increasing national regulations should be resisted as vigorously and continuously as possible. The teaching resource centers we have proposed will operate in individual communities, some as parts of school systems and others under other organizational sponsors. Each should be planned, organized, and managed in terms of its local resources, opportunities, and customs. Similarly, as efforts are made to improve education in mathematics—to achieve something better than the traditional emphasis on computation and better than the original versions of the new math—it is surely teachers and mathematicians in the field, not staff members in Washington, who can best decide what to try and whether what has been tried has worked as effectively as it might.

What is called for is enlightened self-restraint on the part of the National Science Foundation, the Office of Management and Budget, and the Congress. All recognize the principle involved, but in day to day dealing with details staff members are always under pressure to take the "safe" course of increasing central control or adopting another national regulation. Yet principle should be made to prevail. NSF surely does not want authority over the substance of what is taught in the schools. Congress would not want that power to be held by any agency of the Executive Branch nor to arrogate it to itself. The proper role for NSF is to allocate public funds in the encouragement of the best independent initiative. Of course NSF must then see to it that those funds are honestly and competently used for the purposes intended. But decisions as to what educational improvements are most needed and how those needs can best be met are emphatically not decisions to be made by an agency of the federal government.

References

BCMA Associates. "Commerical Curriculum Development and Implementation in the United States." *Pre-College Science Curriculum Activities of the National Science Foundation*, Vol. 2. Washington, D.C.: National Science Foundation, 1975.

Children's Television Workshop plans major new educational series on science for 1980. **CTW News**, October 24, 1978.

Committee on Minorities in Engineering. *Retention of Minority Students in Engineering*. Washington, D.C : National Academy of Sciences, 1977.

Crane, L.T. "The National Science Foundation and Pre-College Science Education: 1950-1975." Report prepared for Subcommittee on Science, Research, and Technology of the Committee on Science and Technology, U.S. House of Representatives by Science Policy Research Division, Congressional Research Service. Washington, D.C.: U.S. Government Printing Office, 1975.

EPIE Institute. "Report on a National Study of the Nature and the Quality of Instructional Materials most used by Teachers and Learners." *EPIE Report*, Number 76, 1977a.

EPIE Institute. "Selectors' Guide for Elementary/Junior High School Science Programs." *EPIE Report*, Number 77, 1977b.

Gibson, C. Survey conducted for the College English Association. **CEA Forum**, 1978.

Hausman, H. J. "Choosing a Science Program for the Elementary School." Occasional Papers Number Twenty-Four. Washington, D.C.: Council for Basic Education, 1976.

Helgeson, S.L., Blosser, P.E., and Howe, R.W. *The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975*. Vol. 1: Science Education. National Science Foundation Report SE 78-73. Washington, D.C.: U.S. Government Printing Office, 1977.

Helgeson, S.L., Stake, R.E., Weiss, I.R., and Easley, J. *The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies*. National Science Foundation Report SE 78-71. Washington, D.C.: U.S. Government Printing Office, 1978.

Holden, C. Science show for children being developed for T.V. *Science* 202:730-731.

Kimche, L. "Science Centers: A Potential for Learning." *Science* 199:270-273.

National Advisory Committee on Mathematical Education. *Overview and Analysis of School Mathematics Grades K-12*. Washington, D.C.: Conference Board of Mathematical Science, 1975.

National Assessment of Educational Progress. *Changes in Social Studies Performance, 1972-76*. Selected Results from the Second Assessment of Social Studies, Social Studies Report No. 07-SS-01., 1978a.

National Assessment of Educational Progress. *Three National Assessments of Science: Changes in Achievement, 1969-77*. Selected Results from the Third National Assessment of Science, Report No. 08-S-00., 1978b.

National Center for Educational Statistics. *The Conditions of Education, 1978 Edition*. Washington, D.C.: U.S. Government Printing Office, 1978.

National Research Council. *Summary Report 1977 Doctorate Recipients from United States Universities*. Washington, D.C.: National Academy of Sciences, 1978.

National Science Foundation. *Science Education—The Task Ahead for the National Science Foundation*. NSF Report 71-13, the "Platt Report". Washington, D.C.: U.S. Government Printing Office, 1970.

National Science Foundation. *Women and Minorities in Science and Engineering*. NSF Report No. 77-304. Washington, D.C.: U.S. Government Printing Office, 1977.

Office of Civil Rights. *Racial and Ethnic Enrollment Data from Institutions of Higher Education—Fall 1974*. Washington, D.C.: Department of HEW, 1976. 337, 472, 788.

Ostendorf, L.C., and Horn, P.J. *Course Offerings, Enrollments, and Curriculum Practices in Public Secondary Schools, 1972-73*. National Center for Educational Statistics. Washington, D.C.: U.S. Government Printing Office, 1976.

Pallone, N., Hurley, R., and Rickard, F. "Further Data on Key Influencers of Occupational Expectations among Minority Youth." *Journal of Counseling Psychology*, 1973. 20:484-486.

Quick, S.K. "Secondary Impacts of the Curriculum Reform Movement: A Longitudinal Study of the Incorporation of Innovations of the Curriculum Reform Movement into Commercially Developed Curriculum Programs." Unpublished doctoral dissertation, Stanford University, 1978.

Roark, A.C. "The Playground of the Museum World: The Free-Wheeling Science Center Has Become One of the Biggest Cultural Attractions in Town." *The Chronicle of Higher Education*, February 13, 1979. 17:8-11.

Schlessinger, F.R., Howe, R.W., White, A.L., Chin, L.F., Baker, J.H., and Buckeridge, E.C. *A Survey of Science Teaching in Public Schools of the United States—1971*, Vol. 1. Columbus, Ohio: The Ohio State University, 1973.

Science Curriculum Implementation Review Group. *National Science Foundation Curriculum Development and Implementation for Pre-School Science Education*. Report of the Science Curriculum Implementation Review Group to the Chairman, Committee on Science and Technology, U.S. House of Representatives, October 1, 1975. Washington, D.C.: U.S. Government Printing Office, 1975.

Stake, R.E., and Easley, J. "Case Studies in Science Education." *National Science Foundation Report SE 78-74*. 2 Vols. Washington, D.C.: U.S. Government Printing Office, 1978.

Suydam, M.J., and Osborne, A. "The Status of Pre-College Science, Mathematics, and Social Studies Education," Vol. II: Mathematics Education. *National Science Foundation Report SE 78-73*. Washington, D.C.: U.S. Government Printing Office, 1977.

Tolman, R.R. "A Look at Achievement Test Score Declines." *Biological Sciences Curriculum Study Newsletter*, November 1976, No. 65:1-11.

Tyler, R.W. "What Are the Educational Implications of Minimum Competency?" *The National Elementary Principal*, January 1979, 58(2):29-31.

Weiss, I.R. "Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education." *National Science Foundation Report SE 78-72*. Washington, D.C.: U.S. Government Printing Office, 1978.

Wiley, K.B., with Race, J. "The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975," Vol. III: Social Science Education. *National Science Foundation Report SE 78-73*. Washington, D.C.: U.S. Government Printing Office, 1977.

Wirtz, W., et al. "On Further Examination." *Report of the Advisory Panel on the Scholastic Aptitude Test Score Decline*. New York: College Entrance Examination Board, 1977.

Wright, G.S. *Subject Offerings and Enrollments in Public Secondary Schools, 1960-61*. Washington, D.C.: U.S. Government Printing Office, 1965.

Zacharias, J.R. "The People Should Get What They Need: An Optimistic View of What Tests Can Be." *The National Elementary Principal*, January 1979, 58(2):48-51.

Notice

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Panel responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

Acknowledgements

Many individuals have contributed data, advice, and general support to the Panel and Staff during the preparation of this report.

The financial support provided by the National Science Foundation (NSF) and the National Academy of Sciences (NAS) has been noted and is most gratefully acknowledged.

The Panel is appreciative of the interest and support of Dr. F. James Rutherford, Dr. Alphonse Buccino, and Dr. Linda Ingison of the National Science Foundation.

Within the National Research Council, the Panel received valuable counsel and assistance from the Commission on Human Resources, especially from Dr. Harrison Shull, Chairman of the Commission, and Dr. William C. Kelly, its Executive Director, who participated in the meetings and joined in the discussions, and from Dr. Richard Crane and Dr. Lloyd Humphreys who served as Commission reviewers for the report.

The assistance of Dr. Douglas Lapp, Science Specialist for the Fairfax County (Virginia) School System, who served as a consultant to the Panel in its meetings and in the drafting of its report, was especially helpful.

Members of the staff of the Commission on Human Resources who assisted the Panel included Mrs. Shirley Davis, Administrative Associate, and Mrs. Lynn Dotson who supplied secretarial support.

To all of these persons, the Panel expresses its warmest thanks.

Chapter Three
Administration and Support Organizations

American Association of School Administrators

The Final Report 123

Appendices

Appendix A Mathematics Education 133

Appendix B A Report to Administrators: The Status of Precollege Science Educational Practices in U.S. Schools 141

Appendix C The Status of Precollege Social Studies Educational Practices in U.S. Schools 147

Association for Supervision and Curriculum Development

Abstract 159

Thanks, We Needed That 159

Mathematics Education, 1955-1975 162

School Science in an Age of Science 166

The More Things Change:. . . The Status of Social Studies 171

What It All Means 175

National Congress of Parents and Teachers, National PTA

Section I: Background 180

Section II: Problems and Issues

- Teacher Issues 181
- Student Issues 185
- Administrator Issues 188

Section III: Summary and Conclusions 190

Appendix A The NSF Status Studies in Science Education Volume Titles, Accession Numbers and Order Information 191

Appendix B Questions Parents Can Ask About

- Science 192
- Mathematics 192
- Social Studies 193

National School Boards Association

Foreword 197

Introduction 197

Retrospect: The NSF-Sponsored Studies 198

Analysis: The NSBA Curriculum Symposium 206

Prospects for Curriculum in the Years Ahead 208

The NSBA Panel on Curriculum Trends and Developments 211

blank page

Summary of the Findings of Three NSF Sponsored Studies on the Status of Precollege Science Education

The Final Report

Raymond G. Melton

Purpose

Each year literally hundreds of government and non-government agencies conduct surveys, research studies, probes, assessments, evaluations, and commission papers to be written, all relating to the field of education. Fortunately, or unfortunately, as the case may be, most of us as school administrators never see nor hear of the results of these many activities. However, from time to time, findings from these activities produce data which is pertinent to the practicing school administrator. Utilization of this data could assist the administrator in areas of public relations, school board relationships, curriculum development, staff development, organization development, and many other areas. Having little time to spend plowing through the jargon, the annotated information, or the tables and charts which are presented in most of these reports, the school administrator chooses to send these reports on to someone else or file them in "File 13."

The intent of this report to you as an American Association of School Administrators (AASA) member is to provide a summary of three extensive studies conducted by the National Science Foundation (NSF) on the areas of precollege science, mathematics and social studies education. School administrators, and in particular school superintendents, need to be well informed about curriculum issues if they are to provide instructional leadership in their districts. This is especially true in those districts where there is no person responsible for district-wide curriculum supervision and coordination.

Even in those districts in which curriculum coordinators and specialists are employed, it is the superintendent who has the primary responsibility for presenting the district's instructional program to the board of education and to the community-at-large. It is important that those people charged with the leadership of curriculum and instruction receive concise, pertinent and relevant information from studies conducted in the various curricular areas. The purpose of this paper is to provide such a reporting.

Background

The National Science Foundation initiated three studies to answer two basic questions:

1. What has been the impact of the two decades of activity to improve science and math in the schools?
2. What is the profile of the situation today?

To answer these questions, the three studies were commissioned as a (1) literature review, (2) national survey, and (3) a series of case studies. The seven volumes which resulted from these duties are:

The Status of Precollege Science, Mathematics and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries

The Status of Precollege Science, Mathematics and Social Studies Education (3 Vols.)

1977 National Survey of Science, Mathematics and Social Science

Case Studies in Science Education (2 Vols.)

To deal with the massive data contained in the seven volumes and to identify implications for school administrators, NSF commissioned AASA to summarize the three reports. AASA asked three members of the AASA-National Center for the Improvement of Learning (AASA-NCIL) Advisory Panel to assist in the project. The three participating AASA members included:

Dr. Allison Jackson, Associate State Director for Vocational Education, State of New Jersey Department of Education, Trenton, New Jersey

Dr. Donald L. Wright, Curriculum Specialist, Montgomery County Intermediate Unit, Blue Bell, Pennsylvania.

This report was published by the American Association of School Administrators, Rosslyn, Virginia.

Dr. J. Zeb Wright, Director, Division of Continuing Education, West Virginia University Medical Center, Charleston, West Virginia

Each was charged with the responsibility of summarizing one or more of the reports from the NSF. It was agreed that quotes and footnotes would be kept to a minimum and that a readable, non-jargon and short summary would be prepared. These three summaries were submitted to AASA to be condensed further for a report to AASA members. The person at AASA responsible for this report was:

Raymond G. Melton, Associate Director, AASA National Academy for School Executives, Arlington, Virginia.

The "summary of summaries" was to look at the findings from an administrator's perspective and indicate implications for field-based school administrators.

Mathematics Education Summary of Findings

Course Requirements

The general requirement in grades K-6 in mathematics show that approximately 25 percent of the states and 40 percent of the districts have minimum instructional time for math. The amount of time allocated for mathematics instruction is considerably longer than for social studies or science. The average amount of time allocated for mathematics in grades K-3 is 27½ minutes. Thirty eight minutes are allocated for mathematics instruction in grades 4-6.

Requirements in mathematics education for high school graduation indicate that 68 percent of the states require more than one year of mathematics between grades 7-12. Seven percent of the states require specific courses in mathematics instruction for graduation. Forty percent of the districts in the nation require one or more specific mathematics courses. Typically, general mathematics (33 percent) and/or elementary algebra (35 percent) are the courses required.

Utilization of standardized test results for diagnosis in mathematics instruction are widespread among the nation's schools. Ninety-three percent of those schools/classrooms containing grades K-6 and 67 percent of the schools/classrooms in grades 7-12 utilize standardized testing.

The "back to basics" movement and competency-based education movement have had a significant impact on mathematics education. Since math is one of **the basics** to be taught, emphasis, financial support and time-on-task in mathematics education have all increased within the past few years. Approximately 35 percent of the states are planning to implement some type of competency-based program in mathematics education by 1980.

Instructional Techniques

Over half of all mathematics classrooms use the lecture method as the primary mode. However, approximately 23 percent of the remaining classes in mathematics do not use lecture method at all. The discussion method is utilized primarily in elementary math grades K-3 and in the junior high school grades 7-9. In elementary mathematics grades 4-6, individual assignments for students is the daily mode used the most. For mathematics classes in the high school grades 10-12, the lecture method prevailed as the most dominant mode of instruction.

Seventy-one percent of all mathematics classes indicated that some daily discussion techniques were used and the data indicated that there was very little variation in the frequency of discussion mode among grade levels. Student reports and projects were not frequently utilized in mathematics classes, and approximately 46 percent of the classes surveyed **never** used them. Library work was a mode which was deemed inappropriate for mathematics classes (74 percent) and was reported as never used as a means of improving student outcomes. Student use of the chalkboard was prevalent in 72 percent of the classrooms and teachers indicated that they used it at least once a week (half of those responding used it daily).

Most mathematics classrooms (62 percent) use tests and quizzes at least once a week. Utilization of student contracts is rare with over 70 percent of all classes not using them at all. Utilization of the results of standardized tests is far more prevalent in mathematics classrooms than in those classrooms of social studies and science.

Computer-assisted instruction, field trips, simulations, guest speakers, teacher demonstrations, brainstorming and games were not frequently reported as modes of instruction for most mathematics classrooms.

Materials, Equipment and Facilities

About two-thirds of all mathematics classes use a single textbook/program. The remaining classrooms use multiple textbooks/programs. Mathematics classes at the elementary level grade K-3 use games and puzzles far more than any of the upper grade levels. While 58 percent of the K-3 classrooms use games and puzzles, the usage decreases rapidly as the grade level increases. Activity kits and manipulative blocks were frequently used in the elementary grades, especially K-3; but by grades 7-9, the frequency dropped to about 33 percent of the classrooms, and grades 10-12 rarely use this type of material.

Metric measurement tools are not frequently used in the lower grades. Grade levels 4-9 utilize metric measurement tools to the greatest extent. There is a significant decrease in the utilization of metric tools in grades 10-12.

Mathematics teachers rated the adequacy of facilities and equipment for mathematics education as adequate. Fourteen percent of the teachers felt that facilities needed improvement, forty-one percent felt that there was a need to improve small group locations, and 33 percent felt that they were dissatisfied with storage space for equipment and supplies.

In all areas, mathematics classes were quite small. There has been an increased availability of equipment such as computers, calculators, metric tools, geometric tools, etc.; however, the demand by mathematics teachers for these tools has decreased. It would generally be assumed that as the complexity of mathematics increased, there would be an equal increase in the demand for utilization of mathematics tools. Yet the data does not bear out this increased demand.

Staffing

The key descriptors of the instructional arrangement for mathematics education are all interrelated with the single teacher classroom concept. Teacher characteristics for mathematics education are consistent and resemble those of science education and social studies education.

Mathematics Education Issues

Certain issues related to precollege math education are revealed by review of the NSF studies. These issues are drawn from the studies themselves and contain questions which school administrators may want to confront in their leadership for learning.

The "Back-to-Basics" Movement. While the "back-to-basics" movement has stimulated and strengthened mathematics education, it has tended to deal primarily with "computational skills" to the exclusion of the so-called "thought problems." It may be cause for concern to de-emphasize this higher level thinking skill.

Inservice Training/Staff Development. For the most part, teachers of mathematics education feel relatively competent in dealing with the content of mathematics. However, many teachers express a desire for assistance in more effectively and efficiently dealing with the process of teaching, classroom management, effective use of materials, and tracking and monitoring students. Inservice efforts in the past have dealt primarily with the content of mathematics or with the implementation of textbooks/programs. More emphasis needs to be given to teaching techniques and classroom management techniques.

Classroom Organization. Despite the recent fervor over declining student achievement rates, the back-to-basics movement, competency-based education, minimum competencies for graduation, etc., the predominant classroom organizational pattern for mathematics education has remained the self-contained classroom at the elementary level and the fixed period schedule at the secondary level. In other words, the way in which mathematics is being taught has not altered despite criticism of the end product of that organizational pattern.

Time-on-Task. With the emphasis of mathematics as an integral part of the back-to-basics movement, the allocated time for mathematics instruction, especially at the elementary level, has increased. For the most part, however, little attention has been given to the idea of "time on task." The actual amount of time that a student is engaged in learning activities is the critical factor, not the allocated time. The issue is: Have teachers been provided with the professional development and support necessary to effectively and efficiently utilize the time allocated?

Science Education
Summary of Findings

Generally speaking, state education agencies in the United States have not been prolific in their establishment of guidelines for science instruction. Only 27 percent of the states have set guidelines for the minimum amount of instructional time to be spent in science, and only 21 percent of the states require more than one year of science for graduation. School districts by and large have been more supportive of the requirements for science education with 47 percent of the nation's districts requiring one year of science for graduation, while 33 percent require more than one year. Almost half (49 percent) of the districts require a specific course in science in grades 9-12, with general science (27 percent), biology (21 percent), and physical science (12 percent) the most frequently required courses. This lack of direction or mandate by federal or state education agencies has left science education as a "non-survival" subject. The tremendous surge of concern for science education in the post-Sputnik era has waned and the back-to-basics and competency-based education movements have relegated science education to the "back burner."

The amount of time spent on science instruction is significantly less than that spent on mathematics or social studies. Students receive an average of 19 minutes per day of science instruction in grades K-3 and an average of 35 minutes per day in grades 4-6. In the junior high school and senior high school, science instruction is offered through courses. The most common science courses offered in grades 7-9 in descending order are: general science, earth science, life science, physical science and biology. General science is the only science course offered by more than 50 percent of all the schools with grades 7-9. In grades 10-12, from most to least frequently offered courses are: biology, chemistry and advanced biology. Nearly 90 percent of all science courses are offered on a full year basis.

In recent years there has been a proliferation of elective courses and/or "mini-courses" being offered to stimulate student interest. These elective courses include oceanography, marine biology, plants, mechanics, genetics, electronics, space science, environmental studies and ecological studies. An obvious counter factor to the popularization of science is the "budget crunch" which is forcing some schools to drop previously popular and successful elective courses because of the high cost of providing laboratories and other types of "hands-on" experiences.

The fact that science education has not been generally included in the back-to-basics or competency-based education movements has obviously affected the emphasis placed on the subject by educators at all levels. Only 13 percent of the states are planning to establish basic science competencies which students must attain prior to graduation. It is obvious then that there is a lack of any type of accountability system which would require school districts to emphasize science education instruction at either the elementary or secondary levels.

Instructional Techniques

Instructionally, science education relies heavily on the lecture method and class discussions as modes of instruction. Half of the classes require a student report or project and/or an individual assignment at least once a month. Laboratory experiences or other types of hands-on, participatory activities are used by about half of the science classrooms with a frequency of at least once per week. Teacher demonstration and utilization of the library and other resources are other techniques used by approximately one-third of the science classes.

Techniques never used in many science classes include televised instruction (69 percent), programmed instruction (71 percent), computer-assisted instruction (90 percent), contracts (78 percent), simulations including role playing, debates, panels, etc. (61 percent), and guest speakers (54 percent). About half of all class time in science is spent with the entire class as a group, about 20 percent of the time students meet in small groups, and students work individually about 30 percent of the time.

Materials/Facilities

Approximately half of all science classes use a single published textbook/program. Another 20 to 30 percent of the classes use multiple textbooks/programs. Very few classes use no textbook/programs except for 37 percent of the K-3 classes. Between half and two-thirds of the science classes use textbooks/programs which have accompanying supplementary material. Teacher manuals which accompany textbooks are extensively used.

Schools are more likely to have budgets for science supplies than for science equipment. Nearly all secondary schools (95 percent) have microscopes as do most elementary schools (80-90 percent). Other types of equipment available in a majority of schools are scientific models at all grade levels, cameras at grades 7-12, and hand-held calculators and dark rooms at grades 10-12. In general, suburban schools are the best equipped followed by urban schools, with small cities and rural areas being the least well equipped. Schools in large districts tend to be better equipped than those in small districts.

Staffing

The number of professionals at both the state and local levels who are specifically assigned to supervise science education has been reduced in recent years. Only 55 percent of the states have science education specialists who devote more than 75 percent of their time to state-wide coordination. Likewise, in most school districts, only 37 percent have a district supervisor. Districts in the Northeast or South, urban or suburban districts, and those median to large in size are most likely to employ one or more district supervisors. At the school level, a considerable number of principals perceive themselves as "not well qualified" to supervise science instruction. In addition, there are few elementary and junior high schools which have department chairmen to offer instructional help to science teachers. However, 80 percent of the schools in grades 10-12 have department chairmen.

The average number of years experience for elementary teachers is 10.5 years; for grades 7-9, 11.5 years; and for grades 10-12, 11.8 years. Thirty percent of 4th through 6th grade science teachers have a degree beyond a bachelors degree. Fifty percent of 7th through 9th grade teachers and 54 percent of 10th through 12th grade teachers of science have earned a masters or doctorate degree. The ratio of female to male science teachers for grades 4-6 is 2 to 1, for grades 7-9 is 1 to 2, and for grades 10-12 is 1 to 3.

Science Education Issues

Certain issues related to precollege science education are revealed by review of the NSF studies. These issues deal with the following topics: the back-to-basics movement, adequacy of facilities and materials, centrality of the textbook, new science topics, discipline, controlling and financing science education, cost effectiveness, inservice training, and elitism. The order of topics does not imply a prioritization.

The Back-to-Basics Movement. Science education is not viewed as "basic" by the general population or educators. Concern for science education is included only in the category of "fundamental knowledge in other areas," which is considered the catch-all for all other subjects not deemed to be "basic."

Adequacy of Facilities and Materials. The importance of the adequacy and availability of science facilities, equipment and supplies is an obvious factor in providing an effective and efficient science program. More than two-thirds of a national sample of science teachers felt that there were inadequate facilities, insufficient funds for purchasing equipment and supplies, and a lack of materials to individualize instruction. Inadequate room facilities and lack of supplies and equipment are the number one and number two barriers to teaching science at the elementary level. Even in those schools and school systems where facilities and equipment are available, they are in many cases run down, out of date, and/or in need of repair.

Textbooks. Fifty to eighty percent of all science classes use a single text or multiple texts as **the** basis for instruction. The textbook has become the curriculum and the source of expertise in many classrooms. Given the facilities available, the textbook as the curriculum, and the teaching modes employed by teachers, it is apparent that science education deals primarily with the lower levels of thinking, e.g., knowledge and comprehension as opposed to application, analysis, synthesis, or evaluation (Bloom's Taxonomy).

New Science Topics. The proliferation of new topics in science has attempted to stimulate interest in science while also posing serious problems in science instruction. These new courses have strengthened the textbook as the curriculum and have relied heavily on theory rather than on observable data. The new courses have also "broken the mold" of standard laboratory procedures: arrange material or equipment, observe phenomena, record phenomena, and interpret observations by answering questions.

Discipline. Classroom management is seen by teachers as the primary deterrent in effective and efficient instruction. In some classes, up to 50 percent of the class time is lost due to confrontations, distractions, and disruptions. It is felt that a source of the discipline problems is the lack of student interest and motivation in science. Teachers also feel that the support for the teacher is weak in many schools.

Financing Science Education. Sources of support for science education have dwindled since the late 1960s. Federal support for science education has decreased and state support has followed suit. Where science education has not been included in those areas emphasized by a given state, it has suffered. This decrease in support has occurred at a time when support has increased for the more "basic" subjects.

Inservice Training/Staff Development. There is increased emphasis on staff development programs as a means of updating and/or changing science education and instruction. At the elementary level, many teachers feel that their training has been inadequate to teach science. Therefore, staff development programs become a vehicle whereby their skills, knowledge and attitudes regarding science education can be altered. As science education enrollments decrease, there is a tendency for the most experienced teachers to maintain class assignments for science instruction. In these situations, staff development is seen as a tool to update teachers whose professional development experiences may have been many years in the past. Teachers report the greatest need is for obtaining information about instructional materials, learning new teaching methods, implementing the discovery/inquiry approach, and using hands-on or manipulative materials.

Elitism vs. Popularism. As students typically matriculate to higher levels of science instruction, a natural elitism is developed. Only a few students take chemistry and very few of only the most able students take physics. Further, many teachers, students, and parents feel that certain science courses are only for the academically elite and enrollment should not be increased. Running counter to the elitism approach is the move to popularize science through courses which deal with science issues of a more contemporary interest. The proliferation of new science topics previously mentioned has come from this effort.

Social Studies Education Summary of Findings

Social studies education has changed little in the past 20 years while, at the same time, it has expanded the most from the tremendous knowledge explosion of the past two decades. A common and vigorously defended purpose of social studies education is "socialization": observance of the mores of the community, submitting personal inclinations to the needs of the community, conforming to the role of "good student," and getting ready for the next rung of the educational ladder. Social studies education is perhaps the closest thing to "values education" which exists in the regular curriculum of the public schools today.

Of the three science areas studied by the National Science Foundation, state requirements are heaviest in social studies. Overall, four to six semesters of social studies are required for graduation in 68 percent of the states. American history is required in 39 states plus the District of Columbia, while world history is required in 15 states. State history, including the state constitution, is required in 34 states. Other requirements include consumer education (6 states), environmental studies (4 states), law-related education (4 states), and civics (5 states).

Twenty-five percent of states and 40 percent of districts set guidelines for minimal instruction time in one or more elementary grades. The average time mandated is 20 minutes per day in grades 1-3 and 30-40 minutes in grades 4-6. However, instructional, curricular, and social "revolutions" have come and gone with little effect upon the formal curriculum and how teachers within classrooms relate that curriculum to America's youth. Forces such as geography and civics have disappeared along with the 12th grade "problems" course, and a proliferation of electives focusing on one or more of the social sciences has evolved.

At the elementary level, the expanding environment continues to be the primary organizing theme. Courses of study from grades K-6 move from the home up through the neighborhood and community to the state, nation, and world. Textbooks are including more non-western world and world affairs in general. Ethnic studies are becoming more numerous. There is some attention to social problems and to understanding oneself.

Despite course title changes, the disappearance of some courses, and the inclusion of some anthropological content in social studies education, generally, social studies is history and geography and quite similar to what social studies was 20 years ago. There appears to be no justification at this time for changing labels from social studies to social science since instruction is rarely about social science, the systematic inquiry into social phenomena.

Materials/Facilities

The studies completed by the National Science Foundation clearly indicate that the textbook is **the** central focus of most social studies classes. No one company or approach to textbook development clearly dominates the commercial market as it may have 25 years ago when Fremont P. Wirth's secondary American history textbook was used by a majority of all school districts in the nation. For 20 years, the NSF has supported the development of social studies curricula in K-12. Of the districts surveyed, 25 percent of elementary schools and 24 percent of secondary schools used one or more of the federally funded materials. Federally funded materials, however, are most associated with the "new" social studies. The materials have not been widely adopted by school systems, but there are indications that these materials have had a profound impact upon the commercial textbook publishers. However, the extent of that influence has not been determined. With the exception of the early primary grades, "virtually all science, mathematics **and social studies** classes are published textbooks or programs" as the primary curriculum source.

Facilities and Equipment

Suburban schools are the best equipped, followed by urban schools. Schools in small cities and rural areas are the least well equipped. This difference is more dramatic, however, in science areas other than social studies, where expensive equipment is not essential. The major needs cited by teachers (more than half) in all subjects and at all grade levels were for paraprofessional assistants and money to buy class supplies on a day-to-day basis. Social studies education has not benefited from the major federal funding strategies with only 12 percent of the National Defense Education Act (NDEA) funds going to social studies and only 30 percent of the school districts receiving funds from the Elementary and Secondary Education Act (ESEA).

Of all the equipment acquired by schools during the gadget-oriented 1960s and early 1970s, it appears that only the overhead projector today is widely and routinely used by the social studies classroom teacher. Studies reveal that most teachers surveyed have access to the overhead and make use of it as an everyday teaching tool. It appears that televised instruction, programmed instruction, and computer-assisted instruction "are rarely used" in social studies instruction.

Staffing

There does not appear to be any great disparity in the age, sex, background, and experience between social studies personnel and those in the other two science areas. Average years of teaching experience in all three subjects is approximately 12 years. Few teachers in K-3 are male; but in 7-9, males constitute 59 percent in the three subject areas and 74 percent in grades 10-12.

More than one-half of all districts report no person responsible for district-wide supervision or curriculum for social studies education. Seventy-five percent of the secondary schools report social studies department chairpersons, but fewer than one-half of junior high or middle schools have chairpersons, and chairpersons at the elementary level are rare.

Staff meetings, district conferences and university courses were the most common continuing education activities for social studies personnel. Teachers indicated that they found the opportunity to share with colleagues more valuable than help they might receive from specialists. Participation in district- or school-based inservice workshops was high; however, the majority felt that inservice or continuing education generally did not help them solve specific problems relating to everyday teaching.

More than 75 percent of the teachers surveyed in social studies education indicated that they do not usually need assistance from a subject matter resource person in lesson planning, actually teaching lessons, or maintaining discipline (discipline did not appear to be a crucial issue among those surveyed). Areas in which a sizable number of teachers would like additional assistance include obtaining information about instructional materials, learning new teaching methods, implementing the discovery/inquiry approach, and using manipulative or hands-on materials.

Issues

Problems for elementary social studies include (1) the belief that social studies (and science) is less important than other subjects such as reading and mathematics, and (2) inadequate teacher planning time. Science and social studies are two subject areas receiving less amounts of instructional attention in elementary grades as a result of back to basics. Teachers are willing, it appears, to tradeoff time and attention to other subject areas in order to prepare students to read and understand complex ideas. At grades 7-12, lack of student interest in the subject and inadequate student reading abilities are viewed as serious problems.

Grouping: The Greatest Dilemma. Inadequate student reading ranks as one of the most persistent problems for social studies teachers. Since the printed word is the major instructional source, students who cannot read or who read poorly pose vexing problems at all grade levels, particularly in the secondary grades.

Attempts to solve this problem have produced a dilemma for many schools. Because a major emphasis in social studies education is on socialization and citizenship, it calls primarily for heterogeneous grouping. Yet, because of the vast differences in learning abilities, it is common for schools to sort students according to achievement—leading to homogeneous grouping. Although the courts have decreed that permanent grouping along these lines (tracking) is illegal, the dilemma has not yet been solved by most school systems. Teachers indicate they cannot cope with a situation in which the achievement levels vary so drastically.

Equal Opportunities. Schools have not moved much beyond the simplest standards in equalizing education among schools. They have done the best in physical facilities, less in instructional supplies and equipment, and the least in teachers. As the studies consistently demonstrate, the teacher in the classroom is the most critical variable—and inequalities in teachers are extreme, especially between affluent and poor schools. In some schools, fully half of all learning time is spent on interpersonal negotiations since "time-on-task" appears to be an important variable in student achievement, and since there do not appear to be great variables in teachers' preparation, physical facilities, and printed resources among schools. It may be that the greatest variable of all across the nation is the amount of learning time within the social studies classroom. An NSF summary succinctly touches this issue by stating, "what science (social studies) education will be for any one child for any one year is most dependent on what that child's teacher believes, knows, and does—and doesn't believe, doesn't know, and doesn't do."

Accountability. Very few states have established basic competencies in social studies (25 percent in 1977), but 35 percent indicate they are planning to implement competency programs in the near future.

Articulation. Articulation is a continuing problem in social studies as in other subject areas. Surveys indicate that supervisors, administrators, and parents, along with classroom teachers, do not want a more regimented course of study but do want better clarification about what is taught. Articulation appears to be best realized when teachers themselves decide what is to be covered and respect those mutually agreed upon understandings. As students matriculate from one level of the curriculum to another (grade level), it is crucial that there not only be understanding but communication between and among teachers to determine what has been taught and what has been mastered.

Social Studies versus Social Science. There are few indications that schools emphasize a scientific approach common to social science disciplines. Sixty-six percent of the respondents felt that the general public does not favor placing a high priority on emphasizing a scientific approach. The majority of teachers viewed their tasks as both smaller and more holistic—smaller in that they are to transmit facts and skills, larger in that they are to prepare (socialize) students in the value system of the community.

There is evidence that there is a reorientation toward performance skills and away from conceptualized experiences. Symptomatic of this trend is the response by 40 percent of senior high students in a national survey that the thing **most wrong** about social studies was its overemphasis on facts and memorization. Lectures and teacher-led/dominated discussions are still the predominant teaching techniques for social studies classrooms. Learning by doing, laboratory experiences, and the more recently espoused learning through induction and inquiry are not widely exercised in social studies classrooms.

Implications for the School Administrator

Based on the summaries of the NSF report, the emerging issues from the data, and the significance of the social/political circumstances affecting education at this time, some very real implications are apparent. These implications for school administrators affect not only science, math, and social studies education but also have transference to the education profession in general.

There are several influencing factors which have had a profound impact on science, mathematics, and social studies education in this country. The post-Sputnik era of emphasis on the development of scientists, mathematicians, and engineers has long since waned and has taken with it much of the motivation within the schools and society itself for continued priority in the subject areas. There has been an equal reduction in the emphasis placed on courses of a nationalistic flavor, such as civics education, American history, American problems, etc., which has had its impact on social studies education. In addition, the emergence of the back-to-basics movement has stimulated emphasis and priority in math while decreasing the emphasis and priority on social studies and science.

The back-to-basics movement has strengthened the notion that the schools cannot be all things to all people and cannot effectively and efficiently assume the social/political/moral responsibilities for educating the "total child." The back-to-basics movement has made it vividly clear that very specific priorities need to be established which have the potential of having the greatest impact upon the greatest number of students. At this time, the areas of reading and math computation have been determined by society, educators, business, etc., as being the two most critical curriculum areas in which all students need a basic foundation of learning. However, while there has been a decrease in the emphasis and allocated time for science education and social studies education at the elementary levels, there continue to be specific requirements for graduation (and in some cases compentencies for graduation) in these same curricular areas. Given the de-emphasis at one level and a continued emphasis at another, one can project a deficiency in the foundation skills, knowledge, and attitudes in science and social studies education as students matriculate to higher levels within the school organization.

A critical issue which has implications for all schools and school administrators is the question of adequate funding. In a period of expanding budgets and decreasing enrollment, one might make the assumption that the increased dollar amounts have proportionately increased the allotments for curricular areas, i.e., math, science, social studies. However, we are all aware that this is not the case. The increased budget has not meant a proportionate increase in the allocations to subject areas. Facilities, equipment, and materials are all governed by the budgetary allotment. There does not seem to be much relief in sight at the local level to give aid to the financial stress.

School districts are being forced to turn to state and federal sources whenever possible. While these resources have provided a boost to the sagging economic situation in many school districts, it has not been extensive enough to meet the needs. It is conceivable that as the budget dollar is stretched to include higher salaries, greater energy costs, additional special services, etc., the quality and quantity of facilities, materials and equipment for math, science and social studies education may suffer. There are increased implications for combining resources within subject areas as opposed to allocations strictly by subject area.

An additional issue is the extent to which the textbook has become the "real" curriculum. All data indicate that regardless of curriculum guides, published objectives, etc., the textbook is the main focus of instruction. The fact is that the textbook publishing companies provide the curriculum. Textbook selection, therefore, becomes extremely critical and must correlate the local requirements, i.e., standardized tests, criterion reference tests, statewide competencies, etc., with the textbook. It is also imperative that the local boards of education and administration be aware that the purchase of textbooks in a given subject area is the purchase of curriculum, not merely materials.

Considerable attention is drawn to the continuation of concern regarding discipline in the classrooms. We are well aware of the results of the Gallup Poll in recent years which indicates discipline as the number one "problem" in the public schools. However, we must realize that this is also the number one problem on the minds of many teachers. The fact that many teachers also indicate that in their perception they are not supported by the administration leads one to the conclusion that, in many instances, there has not been any concentrated effort at providing teachers/administrators with the skills, knowledge, and attitudes necessary to effectively deal with the varied behavior of students. The implication is that to do nothing is to, in fact, not give support. There are proven practices, techniques and programs which are specifically designed to deal with discipline in the schools. These programs, practices and techniques **work** based on documented evidence of teachers and administrators who have used them. There can be little excuse for nothing being done to assist teachers and administrators in handling classroom discipline cases. The implication for the administrator is to do **something**. The specifics about what is to be done, the program to be used, etc., are of secondary importance. The fact is there are things that work and they can be taught to all teachers and administrators in an effective and efficient manner.

The way in which allocated instructional time is put to use in the classroom is becoming an increasingly important factor in the success of the public schools. On the one hand, we see that in many cases the allocated instructional time for mathematics education has increased as a result of the back-to-basics movement; however, there has been a concomitant increase in the degree to which the system is accountable for results with students. On the other hand, there has been a general decrease in the amount of allocated time, especially at the elementary level, in science education and social studies education. In both cases, there are implications for how the time is utilized by the teacher and the extent to which teachers know and utilize the fundamental elements of instruction which lead to student learning. "Time-on-task" is vital for student achievement. The data are conclusive in pointing out that the amount of time-on-task is directly correlated to the amount of student achievement. Data indicate that classroom activities/techniques have remained fairly constant over the past 20 years. The cliche, "teachers teach the way they were taught," cannot continue to be reality if education is to maximize time-on-task and resources.

In an era of declining enrollment and reduction in staff, the importance and significance of a quality staff development program for teachers and administrators is accentuated. With few exceptions, school districts and schools across the nation already have the teachers/administrators under their employment who are to make a difference as to whether or not the schools are successful. Therefore, an ongoing program of upgrading skills, knowledge, and attitudes about all areas of curriculum/instruction/management is necessary. State, federal, and intermediate unit efforts to provide inservice activities can only partially meet the needs that exist. School districts must assume the responsibility for implementing the program of staff development which will assist teachers in getting the job done. Whether it be in the area of classroom instructional techniques, classroom management, communication skills, or whatever, it is critical that some effort be made. It is also critical that school districts continue to utilize the inservice programs provided by state and federal agencies and to increase the participation to a broader sector of the instructional staff.

Conclusions

The United States, more than any other country in the world, practices the doctrine of providing a quality, equitable education for all of its peoples. While we are extremely successful at this venture and have paved the way for others to follow, we have an emerging set of circumstances which could lead to an educational crisis at some point in the future. Comparative studies of international education reveal that our educational system performs poorly in providing students with an adequate background regarding the American political system, democratic responsibilities and, in general, civic or political socialization. These data also reveal that it is through math and science instruction that the economic socialization of a nation is maintained. Our economy demands that we produce scientists, technicians, physicians, engineers and other professionals to utilize scientific information. Science is also important for the citizenry to understand the natural world, natural resources and the potential, or real, threats created by pollution, etc. Therefore, it is critical that the educational system maintain quality instructional programs in the areas of math, science, and social studies. The United States has been able to do this despite the fact that we graduate more students out of secondary school (78 percent) than any other nation in the world.

It is important that we keep in perspective the long-range as well as short-range implications of modifying curriculum and instruction in any of the subject areas in our schools. This is not to say that we should not continually take a critical view of what we are doing, how we are doing it, and the results we are achieving. It is rather to imply that we understand the consequences of our actions, take responsibility for those consequences, and go full speed ahead. To deemphasize or, in some cases, eliminate science and/or social studies instruction at the elementary level is to do our country a disservice. Education must maintain its ability to provide the economic and political socialization of its youth, while at the same time provide for a "basic" skill development.

Appendix A

Mathematics Education

Allison L. Jackson

This report will summarize the findings from the three National Science Foundation Studies, directed at the assessment of the current status and progress in Science, Mathematics, and Social Science curricula in the United States. This effort will focus on mathematics education in the United States and reflect data in the following areas:

- Instructional Modes
- Staffing Patterns
- Materials, Equipment, and Facilities
- Course Requirements
- Graduation Requirements
- Competency ("Back to Basics")
- Implications of NSF Institutes on Mathematics
- Implications for School Administrators
  - Policy implications
  - School Administrator Checklist (designed for this project)

I. Findings

A. General Overview. This report will set the stage for the detailed review of the specific policy, programmatic, and societal issues impacting mathematics education. The basis of these comments is the synopsis of data from the National Survey of Science, Mathematics, and Social Studies Education (1977); and the Status of Precollege Science, Mathematics, and Social Science Education: 1955-1975, Volume II, Mathematics Education. Both reports provide the following profile:

> There is a lack of documentation in the existing data to answer the more subtle questions concerning teacher choices on curricula materials in mathematics.
>
> There is a lack of data specifying the extent to which teachers individualize mathematics instruction.
>
> There is a general lack of data concerning:
>
> > How and why teachers select mathematical content
> >
> > Frequency of use of specific instructional techniques for mathematics teachers
> >
> > Characteristics of teachers who refuse to participate in the NSF institutes, workshops, or conferences
> >
> > Definition of preservice teacher education for mathematics teachers
> >
> > Description of "good practices" used by mathematics teachers for positive student outcomes.
>
> There is a general lack of data concerning the development process for policies impacting mathematics education in the United States. In addition, the need to coordinate and implement valid research for identified problems and specify the inconsistency of funding levels in mathematics education, has grown over the last five years.

B. Instructional Modes. The profile of instructional modes in Mathematics Education utilized in mathematics education in the United States is outlined in the following paragraphs.

1. **Lecture Technique.** This mode was presented as being representative of over half of all mathematics classes daily mode; however, approximately 23 percent of the remaining classes in mathematics do not use lecture method at all. A summary of the techniques selected as most frequently used daily, teachers responded as follows:

Grade Levels	Mathematics Classes	Highest Daily Practices Used
K-3	Elementary Math	Discussion
4-6	Elementary Math	Individual Assignments
7-9	General Math/Algebra	Discussion
10-12	Algebra/Advanced Math	Lecture

2. **Discussion Technique.** Approximately seventy-one (71) percent of mathematics classes

showed daily discussion techniques and there was very little variation in frequency of the discussion made among grade levels.

3. **Student Reports and Projects** were not frequently utilized at all grade levels in mathematics classes, and approximately 46 percent of the classes surveyed never used them.

4. **Library Work** was a mode in which approximately seventy-four (74) percent of all mathematics classes were reported as never using as a means of improving student outcomes.

5. **Individual Student Techniques** featured the chalk board approximately seventy-two (72) percent of the time as a mode for mathematics classes and teachers further specified that they used it at least once a week and one-half of these responded that they used it daily.

6. **Computer-Assisted Instruction** was rare and in approximately ten (10) percent of grades 7-9 math classes and thirteen (13) percent of grades 10-12 math classes, teachers selected this method as a mode of instruction they used.

7. **Tests, Quizzes, and Contracts**. Approximately sixty-two (62) percent of the math classes in the nation use quizzes at least once a week; however, seventy (70) percent of all classes do not use contracts at all. Standardized tests in mathematics far exceed the "teacher made" test of the sciences and social sciences.

8. **Additional Modes** including field trips, simulations, guest speakers, teacher demonstrations, brain-storming, and games, were not frequently reported in mathematics classes. Specifically, eighty-one (81) percent of the classes never use simulations; only eleven (11) percent use guest speakers; and only twenty (20) percent ever use field trips for mathematics classes.

9. **Audio-Visual Materials Impacting Instruction** as films, film loops, tapes, and graphics, were all stressed as "needed but not available" in mathematics education; they are not readily available to teachers so figures such as the following are understandable; i.e., forty (40) percent of mathematics classes reported using a film once a month; twenty-seven (27) percent used tapes and generally the media equipment of the social sciences was not dominant in mathematics.

C. Staffing Patterns in Mathematics Education. The key descriptors of the instructional arrangement for mathematics classes are all interrelated with the "single teacher classroom" factor dominating. The individual mathematics teachers selected two patterns as most significant:

> Small groups of students with the individual teacher (23 percent)
>
> Teacher supervising individual student (34 percent)

D. Materials, Equipment, and Facilities in Mathematics Education. Mathematics classes generally used games and puzzles in the lower grades (K-3, approximately fifty-eight (58) percent usage and frequently more than 50 days per school year). However, game and puzzle usage decreases as the grade level increases. Activity kits and manipulative blocks were frequently used in the elementary grades, especially K-3, but by grades 7-9 the frequency dropped to about thirty-three (33) percent of the time, and grades 10-12 rarely use this type of material.

1. **Metric Measurement Tools** are not frequently used in the lower grades; approximately fifty-three (53) percent of grades K-3 use these tools less than 10 days per school year, whereas grades 4-6, 7-9, and 10-12 use these tools thirty (30) percent respectively. The drop in grades 10-12 is significant.

Selected Equipment—Frequency of Use by Grade Level

Grades K-3

Material/Tool	(Highest) Teacher Response on Frequency of Use
Manipulative tools	More than 50 days
Calculators	Not needed
Computers	Not needed
Metric Measurement Tools	Needed, but not available
Geometric Tools	Use less than 10 days per SY

Grades 7-9

Material/Tool	(Highest) Teacher Response on Frequency of Use
Games and Puzzles	Use between 10-50 days per SY
Hand-Held Calculators	Not needed
Metric Measurement Tools	Used between 10-50 days per SY
Geometric Tools	Use less than 10 days per SY

Grades 10-12

Material/Tool	(Highest) Teacher Response on Frequency of Use
Games and Puzzles	Not needed
Hand-Held Calculators	Not needed
Metric Tools	Not needed
Geometric Tools	Not needed

E. Facilities in Mathematics Education. Mathematics teachers rated the adequacy of facilities and equipment as follows:

Nationally:

Fourteen (14) percent felt that: facilities need improvement

Forty-one (41) percent felt that: there was a need to improve small group locations.

Thirty-three (33) percent felt that: they were dissatisfied with storage space for equipment and supplies

In all areas K-3, 4-6, 7-9, and 10-12 mathematics classes were quite small. The availability of equipment such as computers and calculators was an area of increased use, yet decreased demand by mathematics teachers at all grade levels. For example, only eleven (11) percent of K-3 teachers indicated that computers were available, and most discouraged the need for such equipment and facilities. As the grades went higher the perception was that there was an increased need (grades 7-9 and 10-12 showed eleven (11) and sixteen (16) percent, respectively) yet, decreased demand for computers or hand-held calculators.

F. Course Requirements. The course requirements and offerings in mathematics education in the United States may be summarized as follows:

Grades K-6 Mathematics—the general requirements in grades K-6 in mathematics show that approximately twenty-five (25) percent of the states and forty (40) percent of the districts have minimum instructional time for math, science, and social science. In mathematics, the amount of time for grades 1-6 is considerably longer than for social science or science. Minimum requirements are reflected as:

Grade	% of Districts	Average # of Minutes	Standard Error
K	23	17	1.8
1	36	29	1.2
2	39	31	1.7
3	41	33	1.8
4	40	38	2.7
5	40	38	2.6
6	40	38	2.7

M = 327

G. High School Graduation Requirements in Mathematics. The high school graduation requirements nationally may be summarized as follows:

1. Sixty-eight (68) percent of the states require more than one year of mathematics instruction between grades 7-12.

2. Seven (7) percent of the states require specific courses in mathematics instruction for graduation.

3. Forty (40) percent of the districts in the nation require one or more specific mathematics courses—typically, general mathematics (33 percent) and/or elementary algebra (35 percent).

a. **Standardized Tests in Mathematics.** The percent of districts using standardized tests in mathematics in the nation are:

Mathematics	Yes	No
Grades K-6 (M = 310)	93%	7%
Grades 7-12 (N = 302)	67%	32%

b. **"Back-to-Basics Movement" or Competency in Mathematics.** A number of states are planning basic competency in mathematics programs. Approximately 35 percent of the states are planning to implement a competency program in 1979. This trend seems here to stay.

1. **The Course Offerings** that append this movement may be amplified by the responses of the principals participating in the National Survey of 1977. For mathematics education the principals of grades 7-12 were sampled and asked to specify course offerings in the study. The mathematics programs were broken down to

grades 7-9 and 10-12 and the researchers indicated that their data was limited in this area. The generalizations drawn from the preliminary results are reflected as follows:

Grades 7-9

One hundred (100) percent of Grades 7-9 surveyed offered—General Math

Thirty-seven (37) percent of Grades 7-9 surveyed offered—any Algebra

Nine (9) percent of Grades 7-9 surveyed offered—any Geometry

One (1) percent of Grades 7-9 surveyed offered—Calculus and/or Advanced Mathematics.

Grades 10-12

Seventy-eight (78) percent of Grades 10-12 offered General Math.

Ninety-nine (99) percent of Grades 10-12 offered Algebra.

One hundred (100) percent of Grades 10-12 offered Geometry.

Eighty-three (83) percent of Grades 10-12 offered Calculus and/or Advanced Mathematics.

The most commonly offered mathematics courses were:

General Math	(64%)
Algebra	(38%)
Remedial Math	(9%)

The average class size in mathematics programs was:

Grade	# of Students
K-3	24.2
4-6	27.7
7-9	26.7
10-12	23.6
Total Grades	25.5

II. Implications from NSF Study for Mathematics

A. **Teacher Qualifications and Participation.** The percent of mathematics staff who participated in the National Science Foundation Institutes were as follows:

Attendance in NSF Institutes, Conferences, Workshops

	Percent Attending		
Position	Yes	No	Missing
State Supervisors	77	21	2
K-6 District Specialists	18	63	19
7-12 District Specialists	39	54	8
Principals	10	85	5
Teachers:			
Grade — K-3	5	87	9
4-6	5	85	10
7-9	25	67	8
10-12	37	60	3

Nationally, the mathematics teachers showed the least involvement in the NSF institutes (i.e., Grades 7-9, twenty-five (25) percent participation).

Participation in the NSF Summer Institutes has been reflected as forty-three (43) percent of the state supervisors in mathematics attended; (15) fifteen percent attended the Administrators' Conferences nationally and the **use of federally funded curriculum materials** indicated that:

Selected Math Groups
Percent of Math Curricula Materials Developed
by the National Science Foundation

Source/User	K-3	4-6	7-9	10-12
Teachers	60	62	52	54
Principals	28	38	11	8
Curricula Specialists	21	39	29	15
State Department Personnel	1	2	4	4
Professional Publications	24	23	33	38
Professional Meetings	3	8	20	18

Nationally, mathematics teachers had a very low rate of usage of NSF materials:

Grades	Yes	No	Unknown
K-3	8	80	12
4-6	10	80	11
7-9	10	84	6
10-12	11	86	3

During the 1976-77 survey, ninety-two (92) percent of the administrators reported that they did not use NSF mathematics curricula materials (grades K-6); ninety-one (91) percent did not use them for grades 7-9, and ninety-one (91) percent in grades 10-12 did not use the materials.

B. **Textbook Utilization.** The most commonly utilized textbooks and programs in mathematics will be listed; however, about two-thirds of all mathematics classes use a single textbook/program. Only thirty-two (32) percent of all classes use multiple textbooks.

Selected commonly used textbooks:

K-6—	"Holt School Mathematics" (Nicohols) "Mathematics Around Us" (Bolster)
7-9—	"Holt School Mathematics" (Nicohols) "Exploring Modern Math" (Keecly) "Modern Algebra" (Dolciani) "Elementary Algebra" (Denholm)
10-12—	"Algebra" (Dolciani) "Modern School Mathematics" (Jurgenson) "Geometry" (Jurgenson)

III. Implications from Mathematics Studies for School Administrators

The implications for school administrators will be divided into parts:

Conclusions from Status of Precollege Science, Mathematics, and Social Science Education: 1955-1975. Volume II, Mathematics Education

Conclusions from the 1977 National Survey of Science, Mathematics, and Social Studies Education

A. **The 1955-75 Study** indicated a list of deficiencies, influences, and recommendations concerning the examination of the record of mathematics education.

Specific Implications for School Administrators

Change has resulted from federal intervention into mathematics education and there are several policy implications which are significant results of this intervention.

Mathematics education has benefited from federal resources; however, money is not "the universal solvent for educational problems." Future efforts must be directed at the wise investment of money for efficient operation of programs.

This may be accomplished by:

1. **Recognizing the deficiencies in policy formulation, particularly at the local level. The main** sources of insufficiency in mathematics are:

   a. Policy development without accurate information or rational processes

   b. Policies are developed without use of readily available data

   c. The struggle over values in policy formulation, i.e., community, social, economic, et cetera.

B. **Practices in Support of the Implications.** The practices which support the above policy deficits are:

1. Lack of accurate data on instructional modes selected by teachers for math programs.

2. There appears to be no **one** organizational pattern which will increase student achievement in mathematics (1955-75 study, page 31).

3. Although much has appeared about "team teaching," modular scheduling, and other approaches in mathematics education, the self-contained classroom at the elementary level and the fixed period schedule at the secondary level have remained the dominant organization pattern.

4. **Curriculum and Content** elements which are reflected in the 1955-75 study may be summarized as:

   a. "New Math" is not an independent phenomenon, but part of a series of developments that have occurred between the 1950s-1960s.

   b. Curriculum reform in math, historically, was directed at the college bound student; however, changes here occurred more rapidly at the elementary level.

   c. Methodology and course content in math have changed since 1965, although curriculum guides vary in format, the content is similar.

   d. Curricula emphases have been maintained on deductive reasoning, exploration, and the structure of math.

5. **Enrollments.** Generally stated enrollment patterns in mathematics courses at the secondary level have increased steadily, especially in advanced mathematics. A large number of mathematics students have utilized one or more of the NSF curriculum materials.

In many studies, however, it is not possible to ascertain the factors which (. . . impact student demand for courses in mathematics) affect the changes in mathematics course selections. Two *studies (Crawford, 1967; Dunson, 1970) in which black secondary schools in the south were surveyed showed that . . . all offered General Mathematics, Algebra I, and Geometry (however) over 50 percent of the students enrolled in General Mathematics. Only large schools offered courses beyond Geometry and only 1 percent of the students were enrolled in these. . . .* (pages 46-74 of 1955-75 Study)

6. **Classroom Activities**

Approximately 20 percent of the elementary school day is allocated to mathematics, with the number of minutes increasing as the grade level advances.

Approximately 70 percent of teacher time is spent on classroom management, not on actual instruction. **The implication**—how time is spent on mathematics is far more significant than the amount of time allocated.

Student performance is higher when more than half of the classroom time is spent on developmental activities in mathematics.

Classrooms have remained constant over the past twenty (20) years; despite innovations predominant patterns are:

Instruction with total class groups

Tell and show followed by seatwork at the elementary level; and homework, lecture, and new homework at the secondary level

Use of the single textbook

No one mode of instruction is considered best

Teachers believe that activity-oriented instruction should be used, but few actually use it (see pages 60-62 of 1955-75 Study)

Teachers find it difficult to group for mathematics instruction

Disadvantaged students can profit from special attention in mathematics

The needs of the gifted and talented are not being served in the 1970s. Enrichment programs are needed, especially in small schools.

C. Evaluation of Mathematics Instruction—Student Performance. There are three basic results of the research which will impact administrator performance for math improvement. These are:

1. Increased role of evaluation (since 1955) to provide guidance for programmatic decisions in mathematics, whereas, prior to 1955 standardized tests were used for decisions concerning students.

2. The increased role of standardized tests in mathematics carries difficulties, as misuse of test results have had damaging results. Achievement tests have been advocated as a fairer mode of appraisal in math.

3. The change in math testing since the early 1960s has come in the form of utilization of criterion-reference tests since behavioral objectives have carried a greater role in curriculum planning.

4. "Instructional objectives and test items compare favorably on content involving knowledge of computation, but not on content concerning geometry, measurement, and other topics. Insufficient attention has been given to the testing of higher order objectives (e.g., problem solving or analytic thought)." (p. 83 of 1955-75 Study)

D. Implications from Needs Assessment of Educational Practices in Mathematics

1. Since relatively little attention has been given by most states to the documentation of the history, status, or needs of math education, administrators (according to Springer; 1973 the Tallahassee Conference; and MCER Report 1975) should recognize the nationally identified needs in K-12 mathematics education as:

a. Improve mathematic education coordination with the community

b. Support promising inservice and preservice teacher training

c. Adapt basic research findings to the math curricula through joint teacher/administrator efforts

d. Support the development of curricula articulation among K-12 levels

e. Develop better techniques for assessing mathematics programs

f. Generate local programs that adapt to the pressures for "back-to-basics" by:

1. Focusing on local practices and trends

2. Assessing programmatic needs in math

3. Impacting classroom practices by involving more teachers in activity learning

4. Improve and expand on the uses from computers and calculators

5. Emphasize the need to develop creative thinking

6. Revise the mathematics curriculum (continuously) to conform to present and future needs of students (Fairburn, 1976, p. 192 of 1955-75 Study)

7. Develop programs to increase the application of statistics and probability at all grade levels

8. Provide for the individual student needs particularly for less able and talented students.

9. Participate in the development of preservice and inservice teacher training to help strengthen teacher competencies in mathematics

10. Develop better programmatic evaluation techniques, particularly at the local level.

Administrator Checklist for Mathematics Education

Allison Jackson

The various factors in this report describe the enormous task ahead for "front line" administrators seeking to improve the quality and efficiency of their mathematics program. The attending checklist is a suggested process for thinking through the major issues of the studies on mathematics.

	After Consideration/Action Check One		
	Yes	No	Consult Staff/Board
Policy Formulation			
1.1 Has the Board of Education received adequate information concerning national, state, and local trends in mathematics education, to decide on the implications for the district mathematics program?	___	___	___
1.2 Have student needs, future trends, and societal pressures been compared to the district philosophy on mathematics?	___	___	___
1.3 Were various community/staff groups involved in the policy formulation?	___	___	___
1.4 What is the change process to be used for mathematics education innovations?	___	___	___
How will you motivate tenured staff for changes in mathematics instruction, facilities, equipment usage, student performance measurement?			
Instructional mode	___	___	___
Facilities	___	___	___
Equipment	___	___	___
Student evaluation	___	___	___
Program evaluation	___	___	___
Operations			
2.1 What is the principal's perception of the current math program, and has this been collaborated with teaching staff?	___	___	___
2.2 Are you using research for implementing changes in the basic math program?	___	___	___
2.3 What is the funding level of your math program and have you prepared a plan for shifts in state, federal, local support in your district?	___	___	___
2.4 Have you conducted a needs assessment in mathematics education which includes the analysis of:			
a. student performance	___	___	___
b. staff perceptions	___	___	___
c. equipment/materials inventory	___	___	___
d. facilities	___	___	___
e. community perception	___	___	___
f. "back-to-basics" agenda	___	___	___
g. basic research on mathematics innovation in the areas of instructional mode, curricula content, special student needs	___	___	___
2.5 Have you assessed the socio-political attitudes and values of your community and compared them to changes needed in math curriculum based on student performance results?	___	___	___
2.6 Is there an articulation between grade levels and individual schools on mathematics curricula?	___	___	___

	After Consideration/Action Check One		
	Yes	No	Consult Staff/Board
2.7 What are the curricula options in mathematics education for your district and have you presented them to the board?	___	___	___
2.8 Have you clarified the federal, state, and local policies impacting mathematics instruction for:			
handicapped	___	___	___
disadvantaged	___	___	___
limited English speaking	___	___	___
females	___	___	___
gifted and talented	___	___	___
minority students	___	___	___
remedial	___	___	___
2.9 Have you considered how your teacher in-service program addresses mathematics education and what "extras" can be negotiated through:			
federal programs	___	___	___
state department personnel	___	___	___
private foundations	___	___	___
local universities and colleges	___	___	___

Appendix B

A Report to Administrators: The Status of Precollege Science Educational Practices in U.S. Schools

Donald L. Wright

I. Overview

This report on the status of precollege science educational practices in the United States schools was commissioned by the National Science Foundation. Through a grant to the National Center for the Improvement of Learning (NCIL) I was invited, along with two other NCIL Panelists, to prepare a concise, readable, jargon-free report to the membership of AASA; my colleagues' reports deal with mathematics and social studies.

The basis for these reports is a series of seven documents produced by the National Science Foundation as a result of a three-way study: an extensive review of the literature, a national survey of educational practitioners, and a series of in-depth case studies of educational programs and institutions. Further information about the original documents is available from NSF.

In setting up the ground rules for this and the other two reports, it was agreed that quotations and footnotes would be kept to a minimum—so I have used none. Also, I have limited input for the "Program Description" section to the seven NSF documents. However, the "Issues" section and especially the "Implications" section are shot through with personal observations and points of view. Again, the main attempt was to aim the report at our constituency, the membership of AASA.

II. Program Description

Content

Course Requirements. Twenty-seven percent of the states have set guidelines for the minimum amount of instructional time to be spent in science. Only 21 percent of the states require more than one year of science for graduation as compared with 68 percent for social studies. Very few states require specific science courses, with the most common required course being biology, and that in only four states. Thirteen percent of the states are planning to establish basic science competencies which students must attain prior to graduation. Forty-seven percent of our nation's school districts require one year of science for graduation while 33 percent require more than one year. By contrast, 75 percent of the districts require more than one year of social studies. Almost half (49 percent) of the districts require a specific course in science in grades 9-12 with general science (27 percent), biology (21 percent), and physical science (12 percent) the most frequently required courses.

Time on Task. The time spent in science instruction in grade K-3 and 4-6 is significantly less than that spent for mathematics and social studies. Students receive an average of 19 minutes per day of science instruction in grades K-3 and an average of 35 minutes per day in grades 4-6.

Course Offerings. The most common science courses offered in grades 7-9 in descending order are: General Science, Earth Science, Life Science, Physical Science, and Biology. General Science is the only science course offered by more than 50 percent of all the schools with grades 7-9. In grades 10-12, from most to least frequently offered courses are: Biology, Chemistry, and Advanced Biology. Nearly 90 percent of all science courses are offered on a full year basis. Three-year high schools tend to offer students a greater diversity of courses, such as physiology and more advanced courses such as Chemistry II and Physics II, than do four year high schools.

Electives. A variety of science elective courses are being offered to stimulate student interest in science and to make science relevant. Course offerings include oceanography, marine biology, plants, mechanics, genetics, electronics, space science, environmental studies, and ecological studies. A counter factor to the popularization of science is the "budget crunch," which is forcing some schools to drop previously popular and successful elective courses.

There is a tendency in regular science courses, particularly in general science, to emphasize things that would be useful in every day living such as personal health and safety and ways to preserve the physical environment.

Emphasis on a basic skills curriculum was an almost universal finding.

Instructional Techniques

Lectures are quite frequently used, with approximately two-thirds of science classes having lectures once a week or more. Half of the science classes have discussions daily and 85 percent have discussions at least once a week. Half of the classes require a student report or project and/or an individual assignment at least once a month. In two-thirds of the science classes, students use hands-on manipulative or laboratory materials at least once a month with about half using them at least once a week. Teachers administer tests or quizzes to one-third of their classes at least once a month and to another third of their classes at least once a week. Teacher demonstrations are given to one-third of the classes once a month and to another third of the classes at least once a week. About one-third of the science classes are required to use the library at least once a month.

Techniques never used in many science classes include televised instruction (69 percent); programmed instruction (71 percent); computer-assisted instruction (90 percent); contracts (78 percent); simulations, including role-playing, detates, and panels (61 percent) and guest speakers (54 percent).

About half of all science classtime is spent with the entire class as a group, about 20 percent of the time students meet in small groups, and students work individually about 30 percent of the time.

About 80 percent of the science classes use films and filmstrips. Overhead projectors are used in about one-third of the science classes at least once a month.

Nearly half of the 10-12 science classes are homogeneously grouped. The average class size by level is K-3, 24; grades 4-6, 27; grades 7-9, 31; and grades 10-12, 23.

Materials-Facilities

Most Commonly Used Textbooks/Programs. Approximately half of all science classes use a single published textbook/program. Another 20 to 30 percent of the classes use multiple textbooks/programs. Very few classes use no textbooks/programs except for 37 percent of the K-3 classes.

The most commonly used high school science textbook(s)/program(s) for Chemistry is *Modern Chemistry* (Metcalfe), and for Biology are *Modern Biology* (Otto), *Biological Science: An Ecological Approach, BSCS Green,* and *Biological Science: an Inquiry Into Life, BSCS Yellow* (Moore).

In grades 7-9, the most commonly used textbook(s)/program(s) for General Science are *Intermediate Science Curriculum Study: Probing the Natural World, Principals of Science Series* (Heimler), and *Modern Science Series* (Blanc); and for Earth Science *Focus on Earth Science* (Bishop).

In grades K-6 the science textbooks most commonly used are *Concepts in Science* (Brandwein), *Science: Understanding Your Environment* (Mallinson), *New Laidlaw Science Program* (Smith), and *Today's Basic Science Series* (Navarra).

Supplementary Materials. Between half and two-thirds of the science classes use textbooks/programs which have accompanying supplementary materials. Teachers manuals which accompany textbooks are extensively used. Publisher-supplied test materials are used by roughly a third of all science classes. Usage of activity cards and audiovisual materials that accompany student textbooks is rather low.

Textbook Selection. Teacher committees and individual teachers are heavily involved in textbook selection, with only 2 percent of the districts not involving teachers in textbook selection.

Budgeting for Science. Schools are more likely to have budgets for science supplies than for science equipment. The average per pupil amount budgeted for science equipment in grades K-6 is $3.05; grades 7-9, $5.03; and the amount budgeted for grades 10-12 is $5.46. The average per pupil amount budgeted for science supplies in grades K-6 is $1.56; in grades 7-9, $3.62; and the amount budgeted in grades 10-12 is $4.02.

Equipment. Nearly all secondary schools (95 percent) have microscopes as do most elementary schools (80 to 90 percent). Other types of equipment available in a majority of schools are scientific models at all grade levels, cameras at grades 7-12, and hand-held calculators and darkrooms at grades 10-12.

In general, suburban schools are the best equipped, followed by urban schools, with small cities and rural areas being the least well equipped. Schools in large districts tend to be better equipped than those in small districts.

Meter sticks and rules, and balances and scales are the most frequently used equipment in science classes. Microscopes are also frequently used, with two-thirds of the junior and senior high school classes using them. Living plants and animals are the most often used science "materials" in elementary classrooms, with magnifying glasses also receiving heavy usage.

Classroom Facilities. Only 4 percent of elementary science classes are taught in laboratories or special science rooms. About one-third of elementary science classes are taught in classrooms with no science facilities at all and half of the elementary classes are taught in classrooms with portable science materials.

District Use of Standardized Tests. Forty-three percent of the districts use standardized tests in science in grades K-6 and 13 percent in grades 7-12. The most common use of standardized tests in science is in reporting results to individual teachers. Other major uses are the reporting of results to students' parents and using results for curricular revision. Less common uses of standardized tests are for placing students in remedial programs and programs for the gifted; for diagnosis/prescription for individual students and for determining topics for inservice education programs.

Staffing

Supervision of Science. The number of statewide science coordinators has been reduced, and many have received assignment of additional duties. Only 55 percent of the states have science education specialists who devote more than 75 percent of their time to statewide coordination. The average amount of money spent per state to support science education is $41,506.

Most school districts (63 percent) have no district supervisors. Districts in the Northeast or South, urban or suburban districts or those medium to large in size are most likely to employ one or more district supervisors. About 20 percent of the districts reported having a person spending 75 to 100 percent of their time supervising/coordinating science.

The most common criteria used by superintendents in the selection of science district supervisors are prior relevant teaching experience, supervisory certification and possession of a Master's degree in a relevant field.

At the school level, one possible source of instructional help is the principal. However, considerable numbers of principals perceive themselves as "not well qualified" to supervise science instruction. Another source of help is the department chairman, especially in grades 10-12 where 80 percent of the schools have chairmen. Few elementary and junior high schools have department chairmen to offer instructional help to the science teachers at those levels.

Teacher Characteristics. The average number of years experience for elementary teachers is 10.5; for grades 7-9, 11.5 years; and for grades 10-12, 11.8 years. Thirty percent of grades 4-6 science teachers have a degree beyond the Bachelor's degree. Fifty percent of 7-9 teachers and fifty-four percent of 10-12 teachers of science have earned a Master's or Doctorate degree. The ratio of female to male science teachers for grades 4-6 is 2 to 1, for grades 7-9 is 1 to 2, and for grades 10-12 is 1 to 3.

Two-thirds of elementary teachers perceive themselves as "very well qualified" to teach reading. One-half see themselves as "very well qualified" to teach mathematics, while only 22 percent feel "very well qualified" to teach science. Sixteen percent of the elementary teachers see themselves as "not well qualified" to teach science.

Professional organizations to which science teachers most often belong are: National Education Association (40 percent elementary, 48 percent secondary); Association for Supervision and Curriculum Development, ASCD, (25 percent elementary, 17 percent secondary); National Science Teachers Association, NSTA (12 percent elementary, 23 percent secondary); and Phi Delta Kappa, PDK (20 percent elementary, 18 percent secondary).

III. Issues

Certain issues related to precollege science education are revealed by a review of the three NSF studies. These issues deal with the following topics: the "Back-to-Basics" movement, adequacy of facilities and materials, centrality of the textbook, new science topics, discipline, controlling and financing science education, cost effectiveness, inservice training, and elitism. Each topic and inherent issues will be briefly addressed. The order of topics does not imply a prioritization.

The "Back-to-Basics" Movement. While there is wide recognition of the strength of the back-to-basics movement in the United States, there is much room for disagreement as to what is "basic". Most people, however, seem to view the basic skills as reading, mathematics (especially computational skills), communication arts, and fundamental knowledge in other areas. Concern for science education is included in only the last category and science is rarely seen as basic by the general population.

Adequacy of Facilities and Materials. The adequacy and availability of science facilities, equipment, and supplies is an important condition necessary to a good science program. More than two-thirds of a national sample of science teachers felt that there were inadequate facilities, insufficient funds for purchasing equipment and supplies, and a lack of materials to individualize instruction.

Studies reported by NSF found that inadequate room facilities and lack of supplies and science equipment are the number one and number two barriers to teaching science at the elementary level. The teaching of elementary science in classrooms with no science facilities and in many cases with no science textbooks makes the problem most acute at that level.

Twenty percent of the junior high schools do not budget for new science equipment or consumable supplies. Seven out of ten junior high schools have a combination laboratory-classroom and 25 percent have no laboratory facilities. Large average class sizes compound the problem.

At the high school level, many laboratories are run down or ill-equipped. In addition, space for preparation, storage, and for small group instruction is often inadequate or lacking altogether.

Centrality of the Textbook. Fifty to eighty percent of all science classes use a single text or multiple texts as **the** basis for instruction. The source of knowledge authority in most science classrooms is not so much the teacher, but the textbook. The textbook, in many cases is the **real** science curriculum. Although each teacher's approach may be somewhat different, the true source of science knowledge to which teachers regularly defer is the textbook. For students, knowing is more a function of reading, digesting, and regurgitating information from the textbook or lab manual than it is of analyzing, synthesizing, and evaluating.

New Science Topics. New topics in the natural sciences create problems for laboratory and demonstration work. Because they rely more heavily on theory than on observable data, courses like oceanography, ecology, tectonic plates, and molecular biology do not "fit the mold" of the standard laboratory procedures: arrange material or equipment, observe phenomena, record phenomena, and interpret observations by answering questions. Recreational science topics/courses pose additional scheduling and administrative problems.

Discipline. There is widespread concern, especially among teachers about student misbehavior in the classroom. Some teachers find it difficult to maintain control of the class and to sustain student interest in the planned lesson. In some classes up to 50 percent of the class time was lost due to confrontations, distractions, and disruptions. One cause of discipline problems is lack of student interest and motivation. Another cause is weak support for the teacher and the school. Student safety is of special concern in the science laboratory, where the need for acceptable student behavior is amplified. Not only are these disruptures frustrating to the conscientious teacher, but very costly to the students who wish to learn, as well as to the taxpaying public.

Cost Effectiveness. There have been very few studies conducted on cost effectiveness of school programs, including science instruction. With ever rising teacher and administrative salaries and fixed costs, the "discretionary" areas of the budget are under seige. Materials and supplies, and maintenance funding is often reduced. Science instruction has experienced reduction in funding while other more "basic" subjects have not. These conditions make it more important than ever to find better, more cost effective ways to sustain, or even improve, science instruction.

Controlling and Financing Science Education. The United States Constitution vests authority over the schools in state government. Since 1955, many states have been steadily increasing their influence over education. Areas of growing state control include school organization, school curriculum, teacher certification, equality of educational opportunity, minimum competencies, and financial support for the schools. Where science education has not been included in those areas emphasized by a given state, it has suffered.

Federal and state financial support for schools has increased since 1955 and support from local sources has decreased. Federal support for science education has decreased since the late 1960s and state support has followed suit. Increased fragmentation of the curriculum occurs in those states which emphasize individual curriculum areas.

Inservice Training/Staff Development. Several factors support the need for more staff development and training for science teachers. At the elementary level many teachers feel that their training has been "inadequate" to teach science. The average length of teaching service and age of secondary science teachers is increasing. At the same time emphasis on science education and funding for it from federal and state sources is declining. Also teachers find it more and more difficult to attend all but the most local of meetings and conferences. Past reliance on advanced degrees or permanent certification requirements is no longer effective. Negotiated contractual agreements also sometimes interfere with local staff development efforts.

Teachers report the greatest need is for obtaining information about instructional materials, learning new teaching methods, implementing the discovery/inquiry approach, and using hands-on or manipulative materials. Keeping up-to-date in content and working with small groups or individuals and across grade levels were other need areas.

The sources of information most often reported by science teachers as very useful were other teachers, journals and professional publications, college courses, local inservice programs, and federally sponsored workshops. Grades K-6 teachers also reported principals and local subject specialists/coordinators as very useful sources. Seven through twelve teachers indicated meetings of professional organizations as another very useful source of information.

Elitism vs. Popularization. Most students take biology, few take chemistry and very few of only the most able students take physics. Further many teachers, students, and parents feel that certain science courses are only for the academically "elite" and enrollments should not be increased. Elitism stems in part from the desirable efforts of teachers to excel and to have students to excel. At the same time there is some feeling that more students could profit from courses beyond general science or biology and that efforts to enroll these students should be increased.

Running counter to the elitism approach is the move to popularize science through courses for many which deal with science-related issues of interest to all citizens. Many new science topics previously mentioned have come from this effort.

IV. Implications

What are the implications of these issues for science education? A brief examination of the perhaps more salient implications follows.

The "Back-to-Basics" Movement. The lack of recognition of science as a "basic" and the consequent lack of support for science education implies a need for legislation at the national and state levels. The influence of nationally legislated programs on activity in science education is well documented.

Science education might also use the push for improved reading, writing, speaking, and mathematical skills to improve instructional techniques that will not only help students master these basic skill areas, but will also result in more effective teaching/learning of science content.

Adequacy of Facilities and Materials. At the heart of the issue of inadequate facilities and materials for science education lies the question of funding.

Given the financial stress of most local school districts, there doesn't appear to be much relief in sight at that level. However, it would appear possible for each district to make **some** budget allocation for science materials at all levels, which is not now the case. In addition, consideration should be given to greater equalization of funding K-12.

The greatest possibility of improving the adequacy of science facilities and materials would seem to be through increased federal funding for that purpose.

Centrality of the Textbook. Many, if not most textbooks, are excellent resources for students and teachers. There is too great a reliance on the textbook, however, as **the** basis for teaching science. One reflection of this overreliance on a single source material is the predominance of the lecture-recitation as an instructional technique. It is recommended that a greater variety of materials and methods be employed in the teaching of science.

New Science Topics. If curriculum developers, teachers, supervisors, and administrators work together they should be able to iron out problems associated with new science topics/courses.

Discipline. Aside from the damage done to individuals, and to human relationships, discipline problems have posed a serious impediment to the teaching/learning of science. Use of a greater variety of science materials and teaching methods would increase student interest and motivation, reducing disruptive behavior. Support for the teacher and the school science program needs to be increased through the cooperative efforts of parents, teachers, administration, and community, including the school board. Board policies should be developed which give teachers and administrators the backing necessary to deal effectively and fairly with discipline problems, reducing time loss and increasing student learning time. The addition of laboratory assistants or paraprofessionals in the science laboratory would also increase learning time and decrease danger to student safety.

Controlling and Financing Science Education. Increased funding of science education at the federal level would generate greater state funding as well. Also greater state emphasis on science education, already enjoyed by the communication arts and mathematics areas in many states, would help increase funding, time, and staffing resources for science. A greater balance in curricular offerings would result.

Cost Effectiveness. Finding more cost effective ways to offer quality science programs requires manipulation of staffing patterns, teaching techniques, space, and materials. Another dimension which deserves more attention is the use of technology such as television and computers. More funding is not always the answer, but national or state funding to encourage more cost effective ways of teaching science would provide incentive and help districts with program developmental costs. Rearrangment of usage of existing state and local funds which place a priority on cost-effective procedures might also prove helpful. A school materials and supplies fund available to teachers or a district "mini-grant" program are examples.

Inservice Training/Staff Development. Unless inservice training and staff development opportunities for teachers are improved, the present knowledge and skill levels of science teachers will grow increasingly outdated and inadequate to meet current demands for effectiveness.

NSF Institutes should be continued and federal funding of new training programs for science teachers undertaken. At the state level, legislation requiring continuing professional growth on perhaps a five-year cycle should receive serious consideration. Regional inservice programs and courses can meet cross-district needs economically and increase the possibility of teacher participation. Some local districts have made inservice time available by scheduling an early dismissal day once or twice each month.

Elitism vs. Popularization. An assumption underlying the elitism issue is that only a few students can cope with advanced courses. However, a major problem for many students is the lack of math skills. Perhaps increased efforts to correct these math weaknesses would enable more students to "handle" advanced science courses. There is merit to the argument that advanced courses should be rigorous, but some encouragement to more students to take advanced science courses may have highly beneficial results both for the students and for science programs.

Appendix C

The Status of Precollege Social Studies Educational Practices in U.S. Schools

J. Zeb Wright

Overview

The National Science Foundation financed and coordinated during the past two years one of the largest assessments of precollege science, mathematics, and social studies ever attempted in U.S. schools. A significant aspect of the examination was an effort to draw generalizations about needs and practices within the subject areas in grades K-12. To accomplish this gargantuan task, three institutions and organizations were contracted to conduct nationally representative surveys of practitioners, in-depth case studies of representative school districts over the nation (crosschecked by means of a national survey), and a twenty year (1955-75) literature review within each subject area.

The Research Triangle Institute accomplished the practitioner survey, the University of Illinois coordinated the 11 case studies, and the Center for Science and Mathematics (CSME) at the Ohio State University surveyed literature on needs and practices. To accomplish the social studies portion of the literature review CSME subcontracted with the Social Science Education Consortium (SSEC). The reports of the three complementary studies are now available in documents SE 78-71 through SE 78-74 from the U.S. Printing Office.

Working with two other members of the Advisory Council of the National Center for Instruction and Learning (NCIL), who are reporting science and mathematics, I have been asked to analyze all reports dealing with social studies and prepare "a readable, non-jargon, and short" summary for members of the American Association of School Administrators.

The informal approach I am taking is to report as much as possible to administrators whose reading time is limited. I will not always take space to cite individual studies, but will attempt to generalize from all three. Some generalizations I share with fellow administrators will be formed from data from only one study if the other two studies offer no contradictions. Readers should also be aware that I have attempted to form generalizations from the thousands of subjective opinions and feelings expressed by practitioners and reported within the three studies. I admit that the clearest pictures in my mind about the general state of social studies in America today were formed from the in-depth case studies, which succeeded in capturing the aspirations, mindsets, instructional prejudices, and the very character of the most important person in the total instructional process—the teacher.

Also to save space, I have avoided many words and phrases which I have been taught **always** to use to restrict assessment statements—"it appears," "of the sample surveyed," "within those classes observed," "one generalization which may be made based on limited data is," and the like. I was asked to "tell it like it is"—without footnotes—so that administrators will most likely read the report.

Social Studies Today

Socialization: the "Preemptive" Aim

A common and "vigorously defended purpose" of social studies is socialization: observance of the mores of the community, submitting personal inclinations to the needs of the community, conforming to the role of "good student," and getting ready for the next rung of the educational ladder.

In one study, socialization is referred to as the "preemptive aim." Those critics who claim that boys and girls are not receiving traditional value training today would be quite surprised to view the extensive evidence that social studies teachers merely miss the chance to discourse on such Americanizing values as subordination to society's needs, maintenance of personal discipline, a "Protestant" work ethic, and competitiveness.

One study reported that learning could be interrupted or set aside to take care of behavior that did not conform to community norms. Subject matter, it was felt, often took a back seat to socialization. Of all the instructional and administrative routines which interrupt time on task, the intrusion of socialization is protested the least.

In a survey item which asked what the most important task of schools should be, there was a great difference in how parents, administrators, and teachers responded. Forty percent of administrators indicated "the human purpose" as most important (parents only 12 percent). Forty percent of teachers indicated "the knowledge purpose." The highest response from parents indicated neither but "the career purpose"—53 percent. It is as though administrators most want students to behave properly, teachers most want them to know something, and parents most want them to get a job (writer's interpretation).

Requirements

Of the three science areas, state requirements are heaviest in social studies. American history is required in 39 states plus the District of Columbia. World history is required in about 15 states. State history, including the state constitution, is required in 34 states. Other requirements include consumer education (6 states), environmental studies (4), law-related education (4), and civics (5). Instruction about the "free enterprise system" must be accommodated somewhere in the curriculum of 14 states. A required study of communism and other totalitarian forms of government is decreasing (7). Overall, four to six semesters of social studies is required for graduation in 68 percent of states, as opposed to 21 percent in each area of mathematics and science.

At the lower levels of instruction, recommended course titles may be issued by district or state boards but requirements normally are set in the context of time. Twenty-five percent of states and 40 percent of districts set guidelines for minimal instructional time in one or more elementary grades. The average time mandated is 20 minutes per day in grades 1-3 and 30 to 40 minutes in grades 4-6.

Scope and Sequence

Social studies in grades K-12 has charged very little during the past twenty years. Instructional, curricular, and social "revolutions" have come and gone with little effect upon the formal curriculum and how teachers within classrooms relate that curriculum to America's youth.

The most notable changes have been the disappearance of courses labelled geography and civics at the ninth grade level and the replacement of the twelfth grade problems course with a proliferation of electives focusing on one or a few social sciences; e.g. psychology and sociology.

Another change has been an infusion of social science concepts and methodologies into existing traditional courses. Several states have moved to integrated courses such as "American Studies" and "World Cultures," in which any or all social sciences may be drawn from as needed.

At the elementary level the expanding environment continues to be the primary organizing theme. Courses of study from grades K-6 move from the homes, up through the neighborhood and community, to the state, nation, and world. Anthropological content, however, is being used more and more in elementary textbooks. Two popular examples of the infusing of social science concepts are *Man: A Course of Study* and Lawrence Senesh's *Our Working World.* A lasting influence of Jerome Bruner appears to the acceptance by textbook writers that almost any concept can be taught at any grade level if presented clearly and appropriately to students. Senesh includes rather high level economic concepts in grade one, and his *Working World* is one of the most widely used of the federally funded project-produced materials.

Textbooks are including more non-western world and world affairs in general. Ethnic studies are becoming more numerous. There is some attention to social problems and to understanding oneself.

The most typical scope of social studies found in schools in 1975 was:

K — The School Community - Home - Self.
1 — Families (Neighborhoods)
2 — Neighborhoods (Communities)
3 — Communities (Cities)
4 — State History - World Geography
5 — U. S. History
6 — World Cultures
7 — World Cultures - (Eastern Hemisphere) - State History
8 — U. S. History
9 — World Cultures - State History
10 — World History

11 — American History - American Studies
12 — Sociology - Government - Psychology - Economics - Anthropology - Geography

Despite a few changes in course titles, the disappearance of several others, and more reliance on social science content and methodologies within grade level courses the reader should not conclude that the "new" social studies have replaced the old. Generally, social studies **is** history and geography—and quite similar to what social studies was 20 years ago.

There is no justification at this time for changing labels to "social science," for social studies "is rarely about social science, the systematic inquiry into social phenomenon."

Textbooks

Since the studies indicate clearly that the textbook is the central focus of most social studies classes, a very important question to ask is: Does one company or another dominate the commercial market?

The answer is no—and much less than in past years when, for example, Fremont P. Wirth's secondary American history textbook was used at one time by perhaps a majority of all school districts in the nation. Following is a list of the most commonly used textbooks/programs by grade level and percentage of use within districts surveyed:

Grades K-6 Social Studies

Laidlaw Social Science Program (King)	14%
Exploring Series	14%
Social Sciences: Concepts and Values (Brandwein)	13%
Contemporary Social Science Curriculum (Anderson)	7%

Grades 7-9 American History

This is America's Story (Wilder)	5%
America: Its People and Values (Wood)	3%

Grades 10-12 American History

Rise of the American Nation (Todd)	7%
History of a Free People (Bragdon)	3%

For twenty years the National Science Foundation has supported the development of K-12 social studies curricula. Of the districts surveyed, one or more of the federally funded materials are used in 25 percent of elementary schools (grades K-6) and 24 percent of secondary schools (7-12). The most commonly used materials and the percentage of districts using each are:

K-6 Social Studies

1. Elementary Social Science Education Program Laboratory Units (SRA)	12%
2. Our Working World	8%

7-12 Social Studies

1. American Political Behavior	12%
2. Carnegie-Mellon Social Studies Curriculum Project (Holt Social Studies Curriculum)	10%
3. Sociological Resources for the Social Studies (SRSS)	7%

Federally funded materials are most associated with the "new" social studies. The materials have not been widely adopted by school systems, but advocates of the development projects point to the impact the materials have had on kinds of materials being developed by commercial publishers. Undoubtedly, there has been an influence, especially on traditional textbooks and supplementary materials, but that influence has not been properly measured.

Unlike two, even one decade ago, social studies personnel cannot complain about availability of commercial materials for the classroom. The materials industry marketed more than 500,000 non-print and 5,000 print materials for K-12 curriculum use in 1976. Certainly a fair percentage was in the area of social studies. In the three science areas, including social studies, 2,800 textbooks were available in that year.

There is little doubt that standard instructional materials are crucial to the social studies classroom. In all three studies, teachers indicated that major reliance was on the textbooks. Except for the early primary grades "virtually all science, mathematics, and social studies classes use published textbooks or programs." Although approximately one-third use multiple texts, most classes use a single textbook.

In a real sense, then, the source of knowledge is the textbook. To an alarming extent teachers' continuing frame of reference is to the text—it means, to some teachers in the assessment, sometimes ignoring spontaneous and partially correct responses from students in order to focus attention back to the text at hand: "Now John, look there at the top of page 102 and read why New York City is a commercial center."

Since students in many classrooms over the nation are trained to seek answers from the text to questions posed by the teacher, there is little wonder that the inquiry/discovery approach associated with "new" social studies suffers.

In most districts teachers are heavily involved in the textbook selection process. Very few districts, however, involve students, parents, or other lay persons in the process. Most surprising to this writer was that few districts use school board members—especially alarming to me since all three assessments tend to confirm the textbook as **the** major curriculum guide.

The "New Social Studies"

Numerous writers during the past two decades have attempted to capture the essence of the "new social studies"; yet, no one author's interpretation has been generally accepted. A valuable contribution of the Social Science Education Consortium, and part of the NSF final report, is a synthesis of the characteristics of the "new social studies," criticisms of the "new social studies," and the disagreements about the nature, contributions, and value of the "new social studies." Because of space limitations, each of the three lists have been shortened.

CHARACTERISTICS

A. **Content and Organization.** 1. Emphasis on the structure of the social science disciplines as basic content and organizing frameworks for the social studies.

2. Emphasis on processes as content: teaching the methodologies of the social science disciplines, teaching students inquiry skills.

3. Greater emphasis on content from the behavioral sciences.

4. Attempts to bring the latest findings and methodologies from the frontiers of research in the disciplines into the classroom, to shorten the time lag between research and implementation.

5. Experimentation with integration of content from several disciplines: interdisciplinary, multidisciplinary approaches.

6. Emphasis on the **separate** social science disciplines and history.

7. Incorporating world, non-Western, and cross-cultural perspectives into the curriculum.

8. Greater attention to values and valuing.

9. Emphasis on cognitive content and processes, with little attention to values and valuing.

10. Greater attention than in the past to controversial social issues.

11. More in-depth study of specific issues, themes, and topics, and less concern for "covering" (surveying) a whole field, such as American history.

12. Greater attention to problems of sequence, both within courses and throughout the entire K-12 curriculum. Emphasis on step-by-step building of skills, concepts, and the like. Considerable experimentation with grade placement of subject matter.

13. Acceptance of the curriculum sequence as it is and working within broad, existing course titles to insert new content into the curriculum.

B. Instructional Approaches and Materials. 1. Heavy reliance on inquiry/inductive/discovery strategies of instruction.

2. Concern for individual differences.

3. Emphasis on academically talented students.

4. Emphasis on the new, Brunerian view of readiness, that any child can be taught anything at any age in some intellectually honest way.

5. Emphasis on giving greater assistance to the teacher through workshops, training films, training books, and extensive teacher's guides describing rationale, objectives, lesson plans, evaluation techniques, and the like.

6. Emphasis on materials as the most important factor in improving instruction.

7. Utilization of a wide variety of media in addition to or in place of a textbook.

8. Provision of all materials essential to instruction.

C. **Development Process.** 1. Curriculum development was viewed as an experimental research-and-development process involving one or more cycles of development.

2. Products were usually turned over to the commercial publishers for final publication and distribution.

3. Curriculum development took a lot of time and money.

4. Development projects brought together a variety of people on their staffs, including scholars in the disciplines, learning themselves, practicing precollege teachers, psychometricians, curriculum specialists, and artists and audiovisual experts.

5. Although people in other roles were acceptable as staff members, projects tended to draw their leadership from the academic disciplines.

6. In short, curriculum development was seen as a **project** type of effort, not a task for an individual or a local committee with limited funds and limited time.

CRITICISMS

A. **Criticisms of the Inquiry/Discovery/Inductive Method as Used in the "New Social Studies."** 1. There is no evidence for the superiority of inquiry methods over other instructional methods.

2. The inquiry method is really seduction rather than induction. Closed-ended "discovery" activities tend to dominate. Students really are being asked to "sleuth out" what are the teacher's (or materials') preconceived notions, using prearranged data packages.

3. There is too little attention to instructional strategies other than inquiry methods, particularly social science inquiry methods. There seems to be an unquestioned assumption that the social scientist's methods are appropriate for children. Such methods have serious limitations and there are many other ways in which children can and do learn.

4. There are certain problems with the use of original source materials, particularly of the historical variety, among them the introduction of irrelevancies and difficult language. Also, overdoing the use of raw data has its dangers, not the least of which is tediousness. Constant inquiry can be as boring as constant anything else.

5. Perhaps not everything should be open to inquiry and questioning.

6. Some methods used commonly by social scientists can intrude upon human rights under certain circumstances; e.g. "participation observation" in the family.

7. It is not always possible to identify discrete elements and sequences of method in order to teach them.

B. **Criticisms Related to the Content of the "New Social Studies."** 1. The "new social studies," following the lead of the new math and new science, have the possibly mistaken notion that there is something identifiable as "the structure of the discipline" for each of the social sciences and that this structure is what should be taught in the social studies. If there are such structures in the social sciences, they are many and there is no consensus about them; further, they are fluctuating constantly, simply because of the nature of the subject matter—human affairs.

2. The "new social studies" developers have ignored sources of the curriculum other than the social science disciplines.

3. The "new social studies" takes an overly cognitive approach.

4. Method has been made an end in itself.

5. There is vastly undue emphasis on teaching generalizations in the "new social studies."

6. The "new social studies" are too narrowly specialized, too much oriented to single disciplines.

7. Several content areas are weak.

8. The "new social studies" teach value relativism and appear to advocate values that are diametrically opposed to those on which our society is based.

C. **Criticisms Related to the Objectives and Rationale of the "New Social Studies" and Its Place in the Social Studies Scope and Sequence.** 1. Little or no attention has been given to elaborating objectives and rationales.

2. Serious questions can be raised about the relevance of social science content and methods for most people, particularly those who are not college bound.

3. The "new social studies" movement has given little attention to problems of scope and sequence in the social studies curriculum.

D. **Criticisms Related to Needs and Characteristics of Users.** 1. The "new social studies" did not pay sufficient attention to the needs and characteristics of students.

> The "new social studies" was directed mainly toward above-average students.
>
> The "new social studies" neglects individual differences among students.
>
> Younger students can't handle moral relativism.

2. The "new social studies" did not pay sufficient attention to the needs and characteristics of teachers.

3. The "new social studies" did not pay sufficient attention to the roles teacher educators (methods teachers) in colleges might play in their development and dissemination.

4. Too little attention was paid to the elementary level by the "new social studies."

5. The "new social studies" did not consider how the new materials would fit with certain administrative conditions.

6. The "new social studies" paid virtually no attention to what parents and other lay persons thought the schools should be teaching.

E. **Criticism of the Developers of the "New Social Studies."** 1. The development teams were overloaded with social scientists and "underloaded" with classroom teachers, educational psychologists, curriculum specialists, methods professors, and others who could have contributed important expertise.

2. Development of curriculum materials should have been left to commercial publishers in the private sector; federal government interference in this traditionally private enterprise was unwarranted and, in fact, dangerous.

3. The attitudes and manners of the "new social studies" developers and advocates have been found wanting in their sense of urgency, missionary zeal, myopia, and arrogance.

F. **Criticisms Related to Evaluation in the "New Social Studies."** 1. The "new social studies" didn't pay much attention to developing student evaluation procedures to go with the new content they were introducing.

2. Little or no formative and summative evaluation was done by the developers of the new materials.

G. **Criticisms Related to Cost.** 1. The materials themselves were too expensive.

2. Implementation of the new materials entailed greater costs in time and money than the materials they replaced.

H. **Criticisms Related to the "New Orthodoxy."** 1. Premature dissemination of "new social studies" ideas, before adequate examination and revision had been accomplished, may have led to a new kind of inflexibility.

2. The "new social studies" was an attempt to install a "national curriculum" in this country.

I. **Criticisms Related to the "New Hype."** The "new social studies" suffer from an overdose of gimmickry (games and such).

J. **Criticisms Related to the Dissemination of the "New Social Studies."** Contrary to hopes and predictions, the "new social studies" have not disseminated widely.

AREAS OF DISAGREEMENTS

1. Single discipline or multi/interdisciplinary.
2. Success in attending to values and valuing.
3. Concern for controversial social issues.
4. Success in attending to problem of curriculum sequence.
5. Applicability to all types of students.
6. Reliability of evaluation of both product and student achievement.
7. Role of academicians in programs' development.

Staffing

The Social Studies Teacher

There does not appear to be any great disparity in the age, sex, background, and experience between social studies personnel and those in the other two science areas. Average years of teaching experience in all three subjects is approximately 12 years. Few teachers in K-3 are male, but in 7-9 males constitute 59 percent in the three subject areas and 74 percent in grades 10-12.

Supervisory Personnel

Curricular help is not always available for the teacher. More than one-half of all districts report no person(s) responsible for district-wide supervision or curriculum coordination. Although 75 percent of secondary schools report use of social studies department chairpersons, fewer than one-half of junior high or middle schools have chairpersons within individual subject areas. At the primary and elementary levels chairpersons are very rare.

Allegiance

Although teachers pay their strongest allegiance to the subject which they teach, especially at the secondary level, this allegiance does not carry over to professional organizations within particular subject areas. In no study reported did membership in local subject area professional organizations approach the majority of eligible teachers. Membership in the foremost organization, the National Council for the Social Studies (NCSS), includes only a small fraction of social studies teachers in the nation. Neither do teachers make wide use of professional literature issued by the organizations. Although participation in professional organizations by supervisory personnel increases at higher levels of responsibility (virtually all state social studies specialists are either directly or indirectly involved in the National Council of State Social Studies Specialists and NCSS), fewer than 50 percent of respondents to one survey indicated attendance at any kind of local, regional, state, or national meeting during the 1975-76 school year.

Renewal

From where, then, do social studies teachers draw their intellectual and pedagogical strength once in the classroom? This question is not answered by the national studies.

For some teachers, the occassional college course is viewed as an extension of preparation **for** the job, not preparation **on** the job. There is criticism by teachers, supported by assessment data, that college social studies teachers are not generally sympathetic to "new" social studies or to the national innovative thrusts which have occurred during the past twenty years. Additionally, assessment data indicates that perhaps a majority of college social studies personnel denigrate the national social studies projects funded by NSF and other sources.

Staff meetings, district conferences, and university courses were the most common continuing education activities. Most schools had inservice workshop days a couple of times a year, organized and staffed by district personnel and consultants. Participation was high in most places. The teachers found them more valuable for opportunity to talk with other teachers than for the help they got from specialists. Inservice education by master teachers was sought.

Many teachers had problems for which they were not getting inservice help. Inservice or continuing education, further, generally is viewed negatively by a majority of teachers. Rather than helping them solve specific problems relating to their everyday teaching, it is "anemic and aimed elsewhere." Teachers clearly pay little heed to it.

According to the several national surveys cited by the studies, teachers look to other teachers as a source of renewal and on-the-job training. Naturally, and this is especially true for social studies, teachers are exposed to many influencing factors through popular media and their own leisure reading.

What does emerge from the studies is that textbooks and teachers' decisions hold sway in what content is covered in social studies classes and that the process of teacher renewal, rather than being monolithic, is an informal one.

Needs

The studies attempted to ascertain needs of teachers in several areas. More than 75 percent indicated they do not usually need assistance from a subject matter resource person in lesson planning, actually teaching lessons, and maintaining discipline (discipline did not appear to be a crucial issue among must schools surveyed). Areas in which a sizeable number of teachers would like additional assistance include obtaining information about instructional materials, learning new teaching methods, implementing the discovery/inquiry approach, and using manipulative or hands-on materials.

Much of this writer's professional life has been spent as an instructional supervisor. The studies led me to wonder, however, just how much value system-level instructional planning has within the individual classrooms. One reported case study, perhaps the most incisive in its analysis of human dynamics within schools, explained:

> *. . . I believe the pressures on the school have erected a situation where the systems responsible for providing the education of children have drawn inward and moved apart. . . . The institutional level (central office/school board), the managerial level (principals), and the technical level (teachers) have always been somewhat different and the situation seems to have worsened. Teachers are responsible for the day-to-day operation of the classroom; principals serve as linkages or buffers between the technical level and the central office, which is concerned with exchange relationships with the environment. . . .*
>
> *Each of the systems now seems to be functioning as a self-contained and separate entity. Mutual support is minimal.*

That pessimistic view is supported by the studies' findings. In all categories from principal up through state department personnel, the majority of teachers surveyed rated supervisors as less than "very useful." A one-line graphic illustration would show a constantly decreasing line as one moves farther away from the classroom. State department personnel, farthest removed, enjoy only an 8 percent acceptance as "very useful."

A message which came to this writer is that teachers are fiercely independent and any decision made to affect the quality of instruction must have the teacher—the individual teacher's—active involvement.

This fierce independence of teachers is best summarized in the words of one who said, "I listened to all the 'facts', innovators, etc., and then went my own way in trying to touch the best I could."

Facilities, Equipment, and Supplies

The average per pupil expenditure in school districts across the nation is $1, 246. Of the National Defense Education Act funds received by districts, social studies received 12 percent, science 36 percent, and mathematics 26 percent. Social studies also was on the short end for Elementary and Secondary Education Act funds. A full 70 percent of all districts reporting received no funds for social studies from any federal sources, private foundations or other sources other than general state aid allocations.

Suburban schools are the best equipped, followed by urban ones. Schools in small cities and rural areas are the least well equipped. This difference is more dramatic, however, in other science areas than in social studies where expensive equipment is not essential. There is a difference, however, in availability of supplies, especially in alternative materials, simulation packages, current printed materials, audio-visual materials, and other commercial products which supplement the textbook and expand the experiences of social studies students.

The major needs cited by teachers (more than half) in all subjects and at all grade levels were for paraprofessional assistance and money to buy class supplies on a day-to-day basis. Many teachers appear to be frustrated by the absense of budgeted funds (be they small) to purchase small items as class needs demand them.

Social studies teachers do not appear to be manipulatively oriented. In surveys, only 24 percent use "hands-on," manipulative materials once a week.

Many educational administrators and supervisors assumed, as did this writer, that summer institutes and other training programs for classsroom teachers were orienting many teachers to "hands-on" tools being developed in national curriculum programs such as the High School Geography Project. There is no evidence from the studies that social studies teachers who attended, for example, National Science Foundation-sponsored training programs, use "hands-on" experiences more than teachers who did not attend summer institutes.

The movement toward use of simulations in social studies classrooms is encouraging—more so than in any other science area.

Not as encouraging is the meager use made of electronic wares. It appears that televised instruction, programmed instruction, and computer-assisted instruction "are rarely used" in instruction.

Of all the equipment acquired by schools during the gadget-oriented Sixties and early Seventies it appears that only the overhead projector today is widely and routinely used by the classroom teacher. Studies reveal that most teachers surveyed have access to the overhead and make use of it as an everyday teaching tool.

Issues

Problems as Perceived by Teachers, Administrators, and Supervisory Personnel

Problems for elementary studies include the belief that social studies (and science) is less important than other subjects, such as reading and mathematics and inadequate teacher planning time.

Science and social studies are two subject areas receiving less amounts of instructional attention in elementary grades as a result of "back to basics." There is evidence from the studies that reading and mathematics consume much of the time formerly devoted to other sciences. For example, grades K-3 spend an average of only twenty minutes per day on both science and social studies. A child unable to read is viewed as a more serious problem by most teachers than a reduction in time spent on social studies. Teachers are willing, it appears, to trade off time and attention to other subject areas in order to prepare students to read and understand complex ideas.

At grades 7-12 lack of student interest in the subject and, again, inadequate student reading abilities are viewed as serious problems.

Grouping: The Greatest Dilemma

Inadequate student reading ranks as one of the most persistent problems for social studies teachers. Since the printed word is the major instructional source, students who cannot read or who read poorly pose vexing problems at all grade levels, particularly in the secondary grades.

Attempts to solve this problem have produced a dilemma for many schools. Social studies, with its stress on socialization and citizenship, many citizens argue, is the one subject in school which most calls for heterogeneous grouping. After all, the Harvard-bound honor student and the slowest student in the class must live in the world together; yet, each type student, it is reasoned, requires different learning approaches, instructional strategies, and materials. It is common for the school, then, to sort students according to this reasoning—leading to homogeneous grouping. The courts have decreed that such permanent grouping, called tracking, is illegal. Despite court decisions, the dilemma has not yet been solved by most school systems. Teachers' testimony indicate that they realize that, by grouping, a potential democratic atmosphere is lost but as one elementary principal summarized the feelings in her school, "They (poor readers) can paint only so many murals."

Individualized instruction is becoming another guise for sorting students. Data from thousands of classrooms in these studies indicate that individualization of instruction is not widely accomplished, however, due partially perhaps to teachers' perceptions of social studies as "a group thing."

Equal Opportunities

Schools have not moved much beyond the simplest standards in equalizing education among schools. They have done the best in physical facilities, less in instructional supplies and equipment and the least in teachers. As the studies consistently demonstrate, the teacher in the classroom is the most critical variable—and inequalities in teachers are extreme, especially between affluent and poor schools.

In some schools, fully half of all learning time is frittered away on interpersonal negotiations (often between teacher and one or a few students). Time on task appears to be an important variable in student achievement. Since there does not appear to be great variables in teachers' preparation, physical facilities, and printed resources among schools it just may be that the greatest variable of all across the nation is the amount of learning time within the social studies classroom.

The curriculum of small, rural schools generally are the most restricted and traditional. It is ironic that high interest electives ("Wild Flowers/Edibles," for example) are more available in large schools of urban and suburban areas where students already have myriad enriching activities and interests to pursue, while in rural, more isolated schools, courses beyond traditional offerings are rare.

The NSF summary of one of the three studies succinctly touches upon one of the central issues of the national assessment:

What science (social studies) education will be for any one child for any one year is most dependent on what that child's teacher believes, knows, and does—and doesn't believe, doesn't know, and doesn't do.

Accountability

Very few states have established basic competencies in social studies (25 percent in 1977), but 35 percent indicate they are planning to implement competency programs in the near future.

Articulation

Articulation is a continuing problem in social studies. Supervisors and other administrators are more concerned than classroom teachers. Results of surveys indicate that even supervisors and administrators are opposed to a higher degree of uniformity within the curriculum. Parents do not want a regimented course of study but want better clarification about what is taught. Interestingly, the smaller the school the more articulation can be accomplished. Articulation appears to be best realized when teachers, themselves, decide what is to be covered and respect those mutually agreed upon understandings.

In larger systems there is little agreement about what subjects should be taught in what courses and little articulation across courses. In districts which mandate a coordinated curriculum there is less attention to social and current affairs. One danger expressed in the studies is that subject matter is currently perceived as "outside" students and not integrated into his/her everyday life. To remove the direction of the course of study further away from current happenings, as they happen, is to make social studies even more sterile for students.

Social Studies Versus Social Science

Among traditional college social science professors it has been fashionable for some time now to refer to innovative efforts in the field as "social sciensy." There is little danger for them to fear!

There are few indications that schools emphasize a scientific approach common to social science disciplines. Sixty-six percent of respondents felt that the general public does not favor placing a high priority on emphasizing a scientific approach. The majority of teachers viewed their tasks as both smaller and more holistic—smaller in that they are to transmit facts and skill, larger in that they are to prepare (socialize) students in the value system of the community.

There is evidence that there is a reorientation toward performance skills and away from conceptualized experiences. Symptomatic of this trend is the response by 40 percent of senior high students in a national survey that the thing **most wrong** about social studies was its overemphasis on "facts and memorization."

Despite sixty years of rhetoric by social studies leaders, such practices as "democratic living," "learning by doing," "laboratory experiences," and the more recently espoused, learning through "induction and inquiry," are not widely exercised in social studies classrooms. To the contrary, lectures and teacher led/dominated discussions "are the predominant technique." At least two-thirds of teachers use lectures once or more a week. In national questionnaires many social studies teachers indicated they use discussions "just about daily."

Controversial Issues

Administrators should have little fear that social studies teachers will embarrass the school or community. The great majority of teachers are personally committed to the task of helping young people accommodate to the educational system—and the community—**as it is.** Teachers, themselves, attempt to fit in the system and be recognized as cooperative members of the school and the community.

Taking sides on controversial issues within a classroom is not the hallmark of social studies teacher—much better, for example, to teach "about" poverty than attempt to change the economic structure. High school political or economic activism among teachers or students is indeed rare and is certainly not the accepted norm. An atmosphere of questioning is not pictured in any of the three studies.

So traditional, non-controversial, and non-valuing are most social studies classrooms that one can see little promise that any measure of "democratic living" or "laboratory experience" will be achieved in most existing social studies programs.

One factor which tends to mitigate against a more open, questioning atmosphere within classrooms, other than the conservative nature of teachers themselves, is the drive by most schools toward better achievement as indicated by standardized test scores. Attitudes, certainly change in attitude, usually is not part of this assessment.

One would be incorrect to assume from the above descriptions, however, that social studies classrooms are sterile places with little or no interaction among students or between students and teachers. The point should be made that there are human processes occurring within the schools, but primarily of a socialization nature.

The Teacher: The Bottom Line

Studies support John Goodlad's findings that though a district or school may have myriad guides and instructional objectives calibrated toward the receptivity of each child to learn does not mean that those understandings extend into the classroom once the teacher closes the door.

There is evidence that the social studies teacher generally is not oriented to prescribed objectivising of the instructional program. They are more, if you please, Macaulayian in that they paint with a subjective brush, with wholesome streaks of what they think students need, rather than orchestrate (a popular phrase of the "new" social studies) different components of a program designed from a distillation of committee pronouncements or proven practices.

There were those, especially at the district and state levels, who really felt about a decade ago that the massive efforts underway in national social studies curriculum projects would change the very nature of social studies content, the way teachers teach, and student achievement. I would think the results of these three national studies are disappointing to those optimists.

Implications for Administrators

Continuing Education

One of the most troubling findings is that the classroom teacher is not supported in his/her instructional role. Inservice programs, effective for "improving organization," should be planned and structured to give teachers assistance with pedagogical problems.

An untapped source in most districts is the master teacher. Administrators should seek out these teachers and make them the center of inservice programs. Evidence from all three studies is that teachers learn most from other teachers.

Teachers are calling for more funds, even federal funds, for districts to: (1) hire and pay resource people to help teachers with their teaching skills, and (2) provide additional institutes for the improvement of teaching. Teachers are not opposed to devoting time to job-related training and administrators should nurture and reward teachers' desires for self-improvement.

Strengthening Citizenship Education

It is ironic that public schools "are being asked to do things we used to pray to God for;" yet, social studies classrooms are so traditionally structured, so tied to content that the potential within the one curricular area in which problems can be discussed, perhaps even partially resolved, is lost. The potential of social studies is further lessened by the rush of schools to "more basic" subjects.

Perhaps social studies in grades K-12 will never become social science, with the resulting scientific approach to problem solving, but it is critical that some of the widely accepted methodologies of the more useful of the social sciences be utilized by the schools. Teachers are under very real pressure, often subtle, to stay within prevailing community norms. Use of the social sciences, particularly sociology, anthropology, and economics, offers teachers the opportunity more objectively and less emotionally to explore problems that may be tearing apart communities, homes, and, perhaps, students themselves.

A traditional historical or geographical context is not the most conducive manner for looking at problems. I feel it is a role of school leaders, administrators and supervisors, to expose their teachers to useful instructional tools. If change in attitude is expected, then better tools are essential.

Parents and the Community

Perhaps it is time that we slow up a bit in developing standards and curriculum guides (61 percent of supervisory time) and **clarify** for parents and the community what it is that we do attempt to teach within grades and subject areas. It is not parents who are pushing for more regimentation or even articulation within schools; parents are demanding that they understand **what** is being taught.

As the studies confirm, textbooks **are** social studies. Boards of education which spend time approving curriculum guides should consider spending at least equal time on the selection of textbooks. Because of textbooks' importance, a case can be made also for involving parents and students.

A Reasonable Request

Social studies teachers interviewed in the studies revealed a great amount of common sense about problems which affect them. The best example is their willingness to give up instructional time in order that students gain basic skills. Equally reasonable is their request for classroom funds to purchase small instructional items as needs arise. Compared to personnel salaries and other constant expenditures, a small monthly allotment to each teacher may be the smallest cost, yet do more to improve classroom instruction than almost any other line-item expenditure.

Social Studies as a "social study"

Administrators everywhere must address the problem of student grouping. Ways must be found to accommodate all levels of student motivation and ability within a common setting. Individualization of instruction appears to be the greatest promise for social studies classes. Segregation, ability grouping, achievement clustering, and all the other mechanical arrangements, which separate future citizens within a school will not lead to the achievement of the most enduring and endearing social studies goal—preparation for life.

Summaries of the

National Science Foundation Reports

were prepared by:

Dr. Allison L. Jackson (Math Education Report)
Associate State Director for Vocational Education
State of New Jersey Department of Education
Trenton, New Jersey

Dr. Donald L. Wright (Science Education Report)
Curriculum Specialist
Montgomery County Intermediate Unit
Blue Bell, Pennsylvania

Dr. J. Zeb Wright (Social Studies Education Report)
Director, Division of Continuing Education
West Virginia University Medical Center
Charleston, West Virginia

The Final Report

Submitted to the National Science Foundation

was prepared by:

Dr. Raymond G. Melton
Associate Director
American Association of School Administrators
Arlington, Virginia

Association for Supervision and Curriculum Development

Summary and Implications of the National Science Foundation Reports on the Status of Science, Social Studies and Mathematics Education

Ron Brandt and Other Members of the ASCD Dissemination Team[1]

Abstract

Status studies sponsored by the National Science Foundation (NSF) show that many of the changes sought in the curriculum reform movement of the 1960s and early 70s have not been achieved. Most NSF projects in mathematics, science, and social studies are not widely used; inquiry and individualization are rare.

The studies document a lack of authoritative information about what is actually taught, what the effects are, and what effects would be if things were done differently. It seems that content and methods vary somewhat from one teacher to another, but textbooks are the basis for much of the curriculum.

Members of the ASCD team assigned to summarize the studies believe the studies imply the following needs:

Instructional Materials:

1. Continued development of high quality instructional materials, with federal sponsorship if necessary.
2. Procedures for periodically redefining what students should learn.
3. A thorough examination of the processes by which textbooks and teachers' manuals are developed, selected, and used—so that they may be improved.
4. Objective evaluation of instructional materials.

Teacher Education and Support:

1. Redefinition of middle management roles to provide more adequate staff development and support for teachers.

2. Mechanisms, such as NSF institutes, to provide for continuing education of teachers.

Knowledge:

1. Knowledge about differences in points of view between teachers and other educators.
2. Knowledge about the change process in schools.
3. Knowledge about effects of various practices and programs.

Thanks, We Needed That

A Report on the NSF Reports

Ron Brandt and Other Members of the ASCD Dissemination Team[1]

There is a scene in an old movie—maybe in several of them—in which a character, confused and afraid, begins sobbing and babbling incoherently. Another character slaps him hard across the face, whereupon he regains his composure and says, "Thanks. I needed that."

Reading the reports of the National Science Foundation (NSF) studies is a sobering experience. Seven thick volumes, the reports are heavy reading in more ways than one. NSF commissioned the studies in the aftermath of two decades of effort at local, state, and national levels to reform curriculum of elementary and secondary schools. The idea was to find out what had been accomplished so far in science, mathematics, and social studies education as the basis for further long-range planning.

The reports are of three types. There is a survey (Weiss, 1978) which summarizes such information as what courses are offered and how many students are enrolled. It also includes self-reports from teachers about the methods and materials they use, the amounts and kinds of help available to them, and so on.

Three extensive literature reviews—one each for science (Helgeson and others, 1978), mathematics

---

[1] Benjamin Ebersole, Baltimore County (Maryland) Schools; Thomas Gibney, University of Toledo (Ohio); Edward Karns, Parma (Ohio) Public Schools; Ruth Long, ASCD Associate Director; Gerald Ponder, North Texas State University, Denton; Ronald Stodghill, St. Louis (Missouri) Public Schools; and Robert Yager, University of Iowa.

This report was originally serialized in *Educational Leadership*, Volume 36, Numbers 5, 6, 7, 8; February, March, April, May 1979.

(Suydam and Osborne, 1978), and social studies (Wiley and Race, 1978)—summarize the most important research reports and other material published from 1955 to 1975.

Complementing the other reports is a set of case studies (Stake and Easley, 1978, Vol. I) each containing the observations and impressions of a qualified evaluator who made an intensive study of a particular school district. Several additional chapters summarize the observations (Stake and Easley, 1978, Vol. II).

The three-way approach (survey, literature reviews, case studies) produces a three dimensional effect. Together the reports present a more complete picture than would any one by itself.

The ASCD team charged with summarizing the findings and suggesting implications viewed the reports in several different ways. First, we selected what we thought was most pertinent to the roles and interests of ASCD members, most of whom are administrators, curriculum directors, supervisors, and others responsible for curriculum and support services.

Second, we looked for the unexpected: points which seemed to us somewhat surprising. Finally, we sought regularities: patterns that occurred repeatedly across sites and studies.[3]

Paradoxically, the first conclusion one might draw from all that information is that we know very little. We do not know for sure what is actually being taught or how it is being taught in classrooms across America. We do not know how it compares with what was taught twenty or thirty years ago, because we did not have that kind of information then either. We do not know much about effects on students—either the effects of what is now being taught or what the effects would be if things were done differently.

For example, NSF has encouraged used of inductive teaching methods, often referred to as "inquiry" or "discovery." Asked if they used inquiry, many teachers reported that they did, but observers who visited classrooms saw little evidence of it (Stake and Easley, Vol. II, p. 12:8). Moreover, the instructional programs which NSF helped develop, many of which incorporate inquiry methods, are not widely used (Wiley and Race, p. 322; Weiss, p. 80).

At least we know that students would benefit if teachers did use inquiry. Or do we? Those who reviewed the research say no such claim can be made. For example, "There is relatively little solid evidence to substantiate the widespread belief (among social studies educators) that 'critical thinking' methods are superior to other approaches" (Wiley and Race, p. 192).

The reports do not have all the answers, then, but at least they help us know what we do not know. Of course, they do much more that that. They tell us that the curriculum reform movement had some influence on American education. Programs developed with NSF support are used in many schools. Quite a few teachers (albeit a minority) continue to teach them as intended by their developers, inquiry and all. Recent materials produced by commercial publishers incorporate many of the ideas introduced by those programs. And a substantial number of teachers are probably better informed, more capable and more confident as a result of having attended summer institutes sponsored by NSF.

We also "know" other things from reading these reports. We may have known them intuitively before, but the reports substantiate them. For example, within a narrow range of possibilities, what is taught and how it is taught vary from one teacher to another. In most cases the content of a single textbook is the basis for the curriculum; the variability is in the emphasis given to topics and in the teacher's personal style.

Individualization and inquiry are rarely used; the most common teaching method is some form of "recitation": the teacher asking questions, explaining, or giving directions; the students listening, answering questions, solving problems, or filling out worksheets.

This situation exists, much to the despair of those who would like to change it, not because teachers are lazy or unimaginative, but apparently because of the realities of life in classrooms. In the articles which follow, we will summarize these realities and then suggest some implications.

---

[3] The rules of anomalies and regularities are borrowed, after a fashion, from Walter Doyle. See his paper, "Classroom Research: Who Needs It?" presented at the annual meeting of the American Educational Research Association, April 1978, Toronto, Canada.

References

Helgeson, S. L., Blosser, P. E., and Howe, R. W. *Science Education.* Vol. 1 of The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Washington, D.C.: U.S. Government Printing Office, 1978.

Helgeson, S. L., Stake, R. E., Weiss, I. R., et al. *The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies.* Washington, D.C.: U.S. Government Printing Office, 1978.

Stake, R. E. and Easley, J. A., Jr. *The Case Reports.* Vol. 1 of Case Studies in Science Education. Washington, D.C.: U.S. Government Printing Office, 1978.

Stake, R. E., and Easley, J. A., Jr. *Design, Overview, and General Findings.* Vol. 2 of Case Studies in Science Education. Washington, D.C.: U.S. Government Printing Office, 1978.

Suydam, M. N., and Osborne, A. *Mathematics Education.* Vol. 2 of The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Washington, D.C.: U.S. Government Printing Office, 1978.

Weiss, I. R. *Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education.* Washington, D.C.: U.S. Government Printing Office, 1978.

Wiley, K. B., with Race, J. *Social Science Education.* Vol. 3 of The Status of Pre-College Science, Mathematics, and Social Science Education. Washington, D.C.: U.S. Government Printing Office, 1978.

Mathematics Education
1955-1975

Thomas Gibney
Edward Karns

Mathematics instruction has changed very little during the period from 1955 to 1975. A single textbook is the main source of content with few other teaching materials used or requested by teachers. Most instruction occurs with total-class groups and is tell-and-show followed by seatwork at the elementary school level, and homework-lecture-new homework at the secondary school level. The self-contained classroom at the elementary school level and the fixed period schedule of the secondary school are still the predominant patterns for mathematics instruction.

What Major Changes Have Taken Place in Mathematics Curriculum Offerings?

CONTENT

Mathematics still remains a required course in elementary school and the content has expanded from arithmetic to mathematics with the topics of geometry, measurement, probability and statistics, graphs, equations, inequalities, and properties of number systems in textbooks. Computation with whole numbers, fractions, and decimals remains the core of the elementary school curriculum. In the eleven districts of the CSSE Study, various forms of pencil and paper mathematics dominated the scene in the elementary schools with little evidence of manipulatives, sets, etc., being used. (Stake and Easley, 1978, 13:18)

The number and variety of courses offered at the secondary school level have increased since 1955, however, the most frequently taught courses are general math, algebra and geometry. (Stake and Easley, 1978, 18:21) Among the new topics were functions, vector approaches to geometry, computer techniques, and calculus. SMSG and other curriculum development groups were evident as the enrollment in secondary school mathematics courses increased, especially in advanced mathematics courses. Most of this increase occurred during the first part of the 1955-1975 period with the 1970s recording small increases in advanced courses and in basic or remedial mathematics. (Suydam and Osborne, 1977, p. 36)

"NEW MATH"

The "new math" phenomenon was a two-decade series of developments that evolved and changed constantly, some topics disappeared and new ones emerged, some topics emerged and disappeared. (Suydam and Osborne, 1977, p. 48) New materials were widely used by the mid-1960s with content and methodology changes attempted. Federal funding through such agencies as NSF, NIE, R&D Centers, and regional laboratories encouraged the implementation of new mathematics topics, materials, courses, and programs. Despite the "new math" thrust and although it is evident that the number and variety of mathematics courses offered in secondary schools has increased since 1955 there appears to be little change in the mathematics instruction in grades K-12. Few efforts were made to educate elementary or secondary teachers concerning the new changes in content and methodology with the result that the single textbook is still the primary source of mathematics curricula with most teachers using no instructional materials except the textbook and the chalkboard.

Few instances of modern mathematics were found in the case studies. For most classrooms around the country, modern math never touched down. In one city, for example, conventional textbooks with 1960 copyright dates were used in 1977. Over one-third of the principals and approximately one-fourth of the supervisors and teachers stated that new math had been a waste of time and money. (Stake and Easley, 1978, 13:65 and 18:34)

Back to Basics

Much discussion concerning the back-to-basics movement has come from the public's belief that pupils have failed to learn minimal computational skills. The issue of back to basics seems to be emphasized more by school board members running for election or candidates for educational administrative positions than by teachers of mathematics. The Gallup Poll of the public's attitudes toward education revealed that the public's most frequent concerns are: to devote more attention to teaching of basic skills, and to enforce stricter discipline. School board members and parents define back to basics as instruction that concentrates upon skills development in reading, writing, and mathematics.

In defining basics, most schools define basics in terms of the "barebone's" technical skills of reading and simple arithmetic operations. (Stake and Easley, 1978, 13:34) The studies found the elementary math curriculum is traditional and dedicated to helping children learn to compute. (Stake and Easley, 1978, 13:20)

The conclusion of reviewing twenty years of mathematics teaching in grades K-12 is that teachers have been and are still stressing mathematics skills at all grade levels but the time spent teaching mathematics in grades K-6 is less than it was twenty years ago because of many new topics that have been added to the elementary curriculum.

What Impact Has the New Math Approach Had on What Happens in Classrooms?

INSTRUCTIONAL STRATEGIES

In most classrooms the teacher is in charge. (Stake and Easley, 1978, 13:59) It was observed that teachers had great freedom to teach largely what they pleased. (Stake and Easley, 1978, 13:37) This type of freedom may have led to the generalized criticism that very little vertical articulation exists within the mathematics curriculum. Articulation between elementary and secondary schools seemed to be a universal problem. (Stake and Easley, 1978, 13:19-20) It is clearly mental discipline that is the focus of the vast majority of teachers of mathematics at all levels beyond the second grade. (Stake and Easley, 1978, 13:18) In the 60s hands-on curriculum projects were developed and promoted. Now the pendulum seems to be swinging back to one teaching source—the textbook. (Stake and Easley, 1978, 15:5)

CLASSROOM SIZE AND MANAGEMENT

Research during the 20-year period from 1955-75 provided little evidence that mathematics achievement was affected by total class size but that the size of the group with which the teacher works on a particular topic may be of importance. Approximately 20 percent of the elementary school day is allocated to mathematics time but far less time is spent on actual instruction. All teachers K-12 spent a large proportion of their time on non-instructional activities such as discipline, classroom routines, money collections, filling out various forms, etc. Achievement was found to be higher in elementary classes where the greater proportion of time was spent on developmental activities and actual instruction by the teacher. (Suydam and Osborne, 1977, p. 76)

EVALUATION

The use of standardized tests was more common in mathematics than in science or social science, and more common in grades K-6 than in grades 7-12. (Weiss, 1978, p. 27) The greatest change in testing over the past 20 years has been the concern for objective-based referenced or criterion-referenced tests rather than norm-referenced tests. (Suydam and Osborne, 1977, p. 83) Also, evaluation is now expected to provide information for curriculum decisions whereas in 1955 the primary use of standardized tests was to help with decisions concerning individual students.

INQUIRY TEACHING

Although much emphasis has been given to the development of inquiry teaching, little is taking place. (Stake and Easley, 1978, 12:8) Many of the materials designed to promote inquiry were still in the schools but seldom used. (Stake and Easley, 1978, 12:5) Teachers felt that higher level study for students was very hard work. (Stake and Easley, 1978, 12:7) In mathematics at all levels, the teaching method was usually one of going over the problems assigned with either the teacher or students working at the chalkboard while others observed. (Stake and Easley, 1978, 19:7)

MATERIALS

Mathematics instruction and the mathematics teachers remain rather traditional. The textbook is the course of study and the teacher's manual is the most extensively used piece of material to supplement the textbook. Hands-on materials that accompany textbooks are used in about one third of the K-3 mathematics classes but little thereafter in grades 4-12. From third through twelfth grade, students had few materials to manipulate. In most classrooms the source of knowledge certainly is still the textbook. (Stake and Easley, 1978, 13:59 and 65) Mathematics teachers hardly ever use other materials such as film loops, slides, television, programmed instruction, CAI, field-trips, guest speakers, etc. (Weiss, 1978, p. 102)

Federally funded curriculum materials in mathematics were being used less in 1976-77 than in previous years. This may imply that many of the ideas and approaches of these materials may now be found in the "conventional" mathematics textbooks.

(Weiss, 1978, p. 78) More than 500,000 non-print instructional materials and an additional 5,000 print marketed for use in the K-12 curriculum in 1976. Of the approximately 28,000 textbook titles marketed for use in mathematics, science and social studies, a relatively small portion of that total were in use in the majority of the nation's classrooms. The ten most used materials in math in the U.S. are clearly traditional programs all quite similar to each other in terms of instructional design and social and personal values systems. (Stake and Easley, 1978, 13:60)

What Type of Supervisory Support are Teachers Receiving in Mathematics Instruction?

Supervisors at the secondary level revealed a preponderance of administrative and teaching loads over supervisory tasks. Between 62 and 96 percent of curriculum supervisors indicated that their primary responsibility is something other than curriculum supervision. (Stake and Easley, 1978, 18:106) About half of the elementary supervisors had supervision as their primary assignment. On the average, supervisors had in excess of 200 teachers with whom they worked. There were very few people available outside the classroom to provide quality control for the curriculum and assist teachers with pedagogical problems. (Stake and Easley, 1978, 16:42-43)

The number of statewide subject area coordinators has been reduced and many coordinators have been assigned additional duties so that they have less time to spend on mathematics education (Weiss, 1978, p. 33) Approximately two-thirds of the local school districts have no district supervisors. (Weiss, 1978, p. 36) and very few districts have full-time mathematics coordinators. (Weiss, 1978, p. 39)

Very few principals K-12 have majored in mathematics and a considerable number of principals indicated that they are "not well qualified" to supervise mathematics instruction particularly in the secondary school. Most mathematics teachers believe they do not need help in lesson planning, teaching lessons, or discipline but they do request help in obtaining information about instructional materials, learning new teaching methods, and using hands-on manipulative materials. (Weiss, 1978, p. 144) (Stake and Easley, 1978, 18:112) Teachers rate other teachers as their best source of new developments in education, while principals rate other principals as their best source of information about new developments in education. (Weiss, 1978, p. 150) Local inservice programs appear to be more useful to educators in grades K-6 than to those in grades 7-12. (Weiss, 1978, p. 154)

Queried as to what support do math teachers in your schools need, math teachers and supervisors both gave emphasis to teacher centers where the teachers can take their concerns. (Stake and Easley, 1978, 18:61) Staff meetings appeared to be for the purpose of improving organizational arrangements and distributing information rather than for the purpose of giving assistance to the teacher with pedagogical problems. (Stake and Easley, 1978, 16:48) Many of the teachers and supervisors reported having attended a number of institutes and inservice courses. About 30 percent of the high school math teachers surveyed in the study indicated that they had attended at least one NSF summer or academic year institute. (Stake and Easley, 1978, 12:7) Most felt they were useful and many would like such offerings. (Stake and Easley, 1978, 16:51, 18:112)

Looking Ahead

Public dissatisfaction with declining achievement scores in mathematics has stressed the need for changing roles for federal agencies, professional organizations, administrators, supervisors, teachers, and parents in curriculum development and teacher preservice and inservice. It seems evident that hand calculators, computers, metric education, and research on pupil learning are going to be sources of change in the future of mathematics education. National and state assessments and competency requirements will also influence the mathematics teaching-learning process.

Areas of teaching performance that will be critical are those related to how mathematics instruction is organized, how mathematics materials are used, and how much time is spent in direct mathematics instruction. Leadership will be needed to promote the concept that adequate supervision must be available from supervisors and/or administrators to assist teachers in organizing mathematics instruction and in the proper utilization of mathematics materials.

School districts must determine their academic role during the school day. Each school district must evaluate its priorities in terms of its instructional time allotments. If mathematics is a high priority subject then sufficient time must be allotted for mastery and application of basic skills. If the public expects teachers to stress mathematics skills, the mathematics instructional periods cannot be shortened or supplanted by other activities. If teachers are given adequate time to teach mathematics and proper supervision they and their pupils will perform well. To help promote this environment is a major goal of the future.

References

Stake, Robert E. and Easley, Jack A. *Case Studies in Science Education*. Findings I, Booklet XIII, Chapters 12, 13, and 14. National Science Foundation, 1978.

Stake, Robert E., and Easley, Jack A. *Case Studies in Science Education*. Findings II, Booklet XIII, Chapters 15, 16, and 17. National Science Foundation, 1978.

Stake, Robert E., and Easley, Jack A. *Case Studies in Science Education*. Booklet XIV, Chapter 18. Survey Findings and Corroborations, National Science Foundation, 1978.

Suydam, Marilyn N., and Osborne, Alan. *The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975*. Volume II: Mathematics Education. Center for Science and Mathematics Education, The Ohio State University, National Science Foundation, 1977.

Weiss, I. R. *Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education: Final Report, Contract No. C7619848*. Center for Educational Research Triangle Park, North Carolina, National Science Foundation, 1978.

School Science in an Age of Science

Robert Yager
Ronald Stodghill

During the post-Sputnik years, the 1960s, attention was focused not only on advancements in space science but on the whole area of science education. Teachers, school leaders, learning theorists, philosophers and most importantly, practicing scientists took a look at what was happening in various phases of science education. They became involved in various facets of science education from curriculum development to teacher training. They set new directions and established many firsts in American public education.

More than a decade has passed and it seems propitious now to take a look at the past, the present, and the future in relation to science education. While much has been written about the developments in this area, three national studies dealing with the curriculum, teaching strategies, and organization/support systems were recently made available which offer significant insights into them. An analysis of this information with suggestion that it be used by school leaders of today and tomorrow is now possible.

Curriculum

The stated goals of the science program include understanding self, appreciating technology, preparing for college, advancing today's culture, and understanding local issues. There is little evidence, however, that the big ideas or stated goals of science education are ever translated into curriculum and classroom practice (Denny, p. 90). Science teachers talk of helping students to become better citizens, i.e., knowledgeable of societal issues, including politics as related to science (Smith, p. 6).

Although the goals for science in the elementary school tend to be stable, it is apparent that the goals for secondary science are in a period of significant transition (Helgeson, p. 190). There are new directions for secondary science. This has resulted in new offerings which emphasize environmental concerns, societal issues, world problems, decision making, and interdisciplinary efforts (Helgeson, p. 21). Identifying, verbalizing, and advancing such new goals is less illusive than implementing them in science classrooms. The newly stated goals have implications for curriculum changes. They also conflict with the general emphasis on the basic skills in the curriculum. Knowledge of science is not considered "basic" by the general public and surely it does not reflect the new focus for science education (Helgeson, p. 192).

Science in the school program can be characterized by one word—textbooks (Denny, p. 42). The science curriculum exists as the facts and concepts which are traditionally packaged in textbooks. The textbook not only determines the content but the order, the examples, the application of that content (Stake, p. 13-5). The influence of teachers occurs in the choice of a textbook—apparently the most important decision in establishing the curriculum or curriculum component identified by a given course (Stake, p. 19-2). Teachers appear to have "faith" in the textbook; they lament "if only the right one could be found" (Stake, p. 13-2). The science curriculum, then, is a set of knowledges and skills rooted in the various disciplines of science and packaged in textbooks (Stake, p. 19-4).

Little real curriculum planning or school articulation of science materials has occurred (Helgeson, p. 190). The textbook determines the science curriculum and relatively few of the textbooks are in use in significant numbers of schools. For example, 40 percent of all schools use Holt's *Modern Biology* with another 40 percent using the BSCS Green and Yellow Version in about equal numbers (Helgeson, p. 26). This means that the biology program in 80 percent of the classrooms can be characterized by analysis of these three textbooks. Approximately 50 percent of all schools use Holt's *Modern Chemistry* and 40 percent use Holt's *Modern Physics* (Sanders, p. 27). Over half of the teachers and classes in secondary science utilize one basic textbook (Weiss, p. 89). Eighty percent of the primary and 90 percent of the intermediate grade teachers base their instruction in science upon a single textbook (Helgeson, p. 17).

Interaction with teachers suggests that reliance upon guides and books and the emphasis upon "given" science content is a way of avoiding the untidy reality that school science is (Hill-Burnett, p. 26). It is safe and comfortable—a way of insuring that the stated and verbalized "bigger" objectives are never approached. Science instruction focuses on content because it is there. There is often the feeling that the content (i.e., the textbook) **might** be needed someday. There is rarely a teacher reference to consumer needs, no reference to current student needs (Hoke, p. 25). There is little enthusiasm for emphasizing science as inquiry or considering inquiry skills as a form of content (Denny, p. 42).

After expenditures in excess of $100 million dollars on science curriculum materials following Sputnik, it is appropriate to question the impact of the NSF supported national programs. About a third of the schools use or have used one of the several NSF programs for the elementary schools (Helgeson, p. 16). About the same fraction of students experienced the CHEM chemistry and PSSC physics course while over 40 percent experienced one of the basic biology versions (Helgeson, pp. 26 and 28). Teachers who tried one or more of the new (NSF) curricula seem to be returning to the old courses and text series (Stake, p. 15-5).

The newer national programs were in increasing use until 1970; since then adoptions and student use of the materials have declined. Stated reasons for the decline include: (1) no room for teacher and student spontaneity, (2) overemphasis upon pure content, and (3) material too difficult (abstract) for most students (Helgeson, p. 181). All of these courses could be characterized as being organized around the structure of the discipline(s) of science. The programs deemphasized "practical science" and emphasized basic concepts and processes (Helgeson, p. 21).

Instructional Strategies

Classical didactic teaching seems to characterize most classrooms. The teacher typically directs assignments, grading, laboratory instruction and evaluation, reviews before tests, and the testing effort. The question and answer approach—if not a lecture—is universally practiced (Smith, p. 90). There is a great deal of "traditional" teaching with little creativity and few examples of teachers with imagination, enthusiasm, and the ability to motivate (Smith, p. 112 and Sanders, Stufflebeam, p. 13). The textbook is the "answer place" for teachers' questions (Stake, p. 13-62). The common sequence or pattern for instruction in science is assign, recite, test, discuss (Stake, p. 13-5). Testing (usually based on facts, concepts, and definition) is a natural procedure and central to classroom control and curriculum structure (Stake, p. 15-12).

It is rare to find a teacher employing creative inquiry in the classroom. This may be caused by the paucity of such teaching models at the college level during preparatory programs (Stake, p. 12-7). Few teachers are engaging students in learning by experience (Stake, p. 15-7). Most teachers consider, with a question and answer approach, the content that is included between the covers of a particular text. The teacher is the source of power in the science class but apparently this power is meaningless without the book.

Since 1955 there have appeared more and more materials calling for student-centered and hands-on instruction. Even when these materials are in use in a given school, however, large numbers of students are rarely involved with them (Helgeson, p. 190). Fewer than half of the teachers report use of any inquiry approaches (Weiss, p. 148). This raises many interesting questions regarding the appropriateness of the national programs of the 1960s—all of which approached science as inquiry and called for it being taught as a "narrative of inquiry." There was an attempt to present science in a way it was known to scientists.

Although attention to individual differences is frequently the subject of discussion, there is little evidence that it is receiving attention in the form of classroom practice. In most instances, science is taught to an entire class with the teacher as the central figure. It is rare to find students engaged in individual activities either in or out of the classroom. The entire class "does" an activity or is involved with the teacher in a discussion. Recent research establishes that certain instructional modes are more effective with certain students (Helgeson, p. 36). However, this finding has resulted in few individualized programs and/or approaches in science. Where such materials are utilized, they appear as supplements to a course and not central to it (Stake, p. 16-55).

Examples of effective science teaching approaching modern goals in the elementary school are rare. Teaching science in the junior high school is primarily by recitation (Stake, p. 19-6). When laboratories are used, they tend to be demonstrations of information already considered or exercises merely used to break the monotony. Almost all questions arise from information in the textbook and most center on terminology and definition. Teachers rely on and believe in the textbook (Stake, p. 19-6).

Over 80 percent of the science teachers use A.V. material with 15 percent of the secondary teachers using both films and filmstrips on an average of once per week (Weiss, p. 112). It was found, however, in one of the case studies, where massive use of media was tried, that it was not successful (Sanders and Stufflebeam, p. 13). Most of the A.V. materials used tend to supplement textbooks and add to the information base. Most provide more basic content for the existing course structure. Fewer than 10 percent of the schools utilize TV or CAI (Weiss, p. 112).

Teachers state that they want advice on pedagogy; they seem open-minded when it comes to teaching style (Stake, p. 18-112). They frequently talk of the lack of class time, less financial support for inservice work, new demands on their non-class time, and other barriers to change in their instructional modes. It is at once apparent that what a given teacher believes, knows, and does as well as what he/she doesn't believe, know, and do represent what science education will be for a given child (Stake, p. 19-1). Instructional materials and curriculum design are not the critical factors (Stake, p. 15-2).

Teachers express great concern for student attitude generally. Given this concern, nonetheless, they continue to be imprisoned by the textbook, existing courses, and traditional instructional strategies. It just may be that such overreliance on textbooks and guides is occasioned by the teachers' inability to conceptualize the dynamics undergirding and supporting the curriculum and student understanding (Stake, p. 15-2).

Organization/Support

Providing strong science programs in schools is not a high priority. Surprisingly it is not considered basic in today's culture—and at a time of cultural, environmental, and resource crisis. Science teachers, rather than recognizing the problems of our time and the erosion of community and societal support, lament enrollment decreases and guard their advanced courses tenaciously (Stake, p. 12-1). Teachers tend to talk and to use the ditto machine to an ever increasing degree (Hill-Burnett, p. 23). Many have curriculum outlines, including objectives, articulation plans, and sequence charts. In practice, however, these bear little resemblance to actual content in textbooks or the strategies employed (Stake, p. 19-7).

On the average state guidelines call for 16 minutes of time on science in kindergarten to 34 minutes in grade 6 (Weiss, p. 22). Time spent on science in the elementary school as reported by teachers averages 17 minutes in K-3 and 28 minutes in grades 4-6 with an average time in K-6 being 20 minutes per day (Weiss, p. 51). Most elementary science is taught in self-contained classrooms with the first departmentalization occurring in grades 6-8 (Helgeson, p. 13). The segregation in science classes in the junior high paves the way for the advanced science sequence at the senior high level (Stake, p. 21-1). Often an accelerated junior high program for the gifted enables the science prone to complete several advanced courses in the various disciplines in the senior high school.

Total enrollments in science increased until 1973 with a leveling off since in terms of percentages; there has been no sharp decline (Helgeson, p. 190). The average science classes have decreased in size during the 1955-75 period (Helgeson, p. 191). A full 50 percent of all students never complete another science course beyond grade 10 (Helgeson, p. 191). Therefore, it is apparent that most science in the secondary school is taught in the junior high school where teachers are least prepared and where the poorest facilities for instruction exist (Helgeson, p. 191).

There is a need for preservice and inservice education to be part of a continuous program (Helgeson, p. 192). Planned inservice programs are infrequent. Sixty-three percent of the districts have no science coordinator (Weiss, p. 36) while 45 percent of the states have no state science education specialist devoting 75 percent of their time to science (Weiss, p. 33). Science specialists (coordinators) are rated generally useful but progressively less so as grade level increases (Weiss, p. 153). Generally, however, science teachers want more help via consultants (Dawson, p. 18-112) and paraprofessionals (Weiss, p. 136).

Inservice programs are rated higher in terms of need by elementary teachers than by secondary teachers (Weiss, p. 154). However, only 14 percent of all science teachers indicate they have had enough help with hands-on materials (Weiss, p. 148). As funds have tightened, support staff has decreased; teachers and students miss it (Hill-Burnett, p. 3). Inservice efforts generally take the form of staff meetings, special inservice days, and enrollment in university courses. A decline in such programs is explained by (1) fewer inexperienced teachers, (2) less incentive for gaining credit and degrees, and (3) fewer dollars for resource persons (Stake, p. 16-48). Teachers continue to be interested in help from universities. They want (1) help with curriculum development (43 percent), (2) special inservice workshops made available (16 percent), and (3) courses specifically oriented to teacher needs (12 percent) (Stake, p. 16-49).

Better articulation of the science program is considered a more serious problem by coordinators than by teachers (Weiss, p. 162). Teachers appear concerned with classroom problems, course issues, and their particular discipline. These concerns result in little real articulation—either vertically with respect to science or with other disciplines (Stake, p. 19-7). The problems are likely to increase as the role of the science coordinator changes. Such persons are now spending more time with interpreting and enforcing new regulations and preparing proposals for increased funding. Less time is thereby available for curriculum matters and for improvement of teaching strategies (Stake, p. 19-26).

Participation in NSF institutes represents a kind of support which was abundant during the 1960s and all but disappeared in 1976. Such institutes were generally rated as excellent vehicles for sharing new ideas and for maintaining content currency (Welch, p. 15). Teachers who participated in such programs tend to use more manipulative material than other teachers (Weiss, p. 107). Unfortunately the majority of science teachers have not participated in NSF and/or OE institutes (Helgeson, p. 191). About 40 percent of the secondary science teachers have attended an NSF institute while 60 percent of the district and state supervisors of science have been involved (Dawson, p. 106 and Weiss, p. 69).

There have been real changes in schools during the past 20 years which have affected science. These include: (1) appearance of paraprofessionals, (2) new instructional technologies, (3) varying levels of desegregation, (4) increased federal funding and the resulting control, (5) larger school districts, (6) more informal instructional arrangements, (7) unionization of teachers (Stake, p. 17-24). School pressures have changed including greater teacher militancy, greater realization of the difficulties involved with "real" teaching, and disappearance of support systems (administration and boards of education separate from teachers, disappearance of area consultants, etc.) (Welch, p. 14).

For all the science learned, the teacher is the "enabler, the inspirator, and the constraint" (Stake, p. 19-1). The status of science education is not surprising for anyone who has studied the past and the current problems in education. The 1960s were boom years with respect to science education. Perhaps we were arrogant; perhaps we were too blind to see the obvious.

The careful analyses of the status of science education in the U.S. provide much challenge for educational leaders—for curriculum and supervisory researchers and philosophers. Self-correction is a basic characteristic of the human endeavor we call science. It is a feature that we could well incorporate into the fabric of science education. It must occur if our "age of science" is not to be our **demise.**

References

Dawson, Elizabeth K. *Booklet 14*. "Survey Findings." 1977.*

Denney, Terry. *Booklet I*. "Some Still Do: River Acres, Texas." March, 1977.

Hoke, Gordon. *Booklet X*. "Vortex as Harbinger." May, 1977.*

Helgeson, Stanley L., Blosser, Patricia E., Howe, Robert W. *The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975*. Volume 1: Science Education. 1977.*

Hill-Burnett, Jaquetta. *Booklet IX*. "Science in the Schools of an Eastern Middle Seaboard City." May, 1977.*

Hurd, Paul de Hart. *Biology Teacher's Handbook*. 3rd Edition. John Wiley and Sons, 1978, page 62.

Peshkin, Alan. *Booklet IV*. "Schooling at BRT: A Rural Case Study." October, 1976.*

Sanders, James R., and Stufflebeam, Daniel L. *Booklet VIII*. "School without Schools: Columbus Ohio Response to Energy Crisis of 1977." January-February, 1977.*

Serrano, Rodolfo G. *Booklet VII*. "The Status of Science, Mathematics, and Social Science in Western City, USA." June, 1977.*

Smith, Louis M. *Booklet III*. "Science Education in the Alte Schools." June, 1977.*

Smith, Mary Lee. *Booklet II*. "Teaching and Science Education in Fall River." May, 1977.*

Stake, Robert, and Easley, Jack. *Booklet 12*. "Findings I." 1977.*

Stake, Robert, and Easley, Jack. *Booklet 13*. "Findings II." 1977.*

Stake, Robert, and Easley, Jack. *Booklet 15*. "Executive Summary." 1977.*

Walker, Rob. *Booklet VI*. "Case Studies in Science Education." Pine City, August, 1977.*

Walker, Rob. *Booklet XI*. "Case Studies in Science Education." Boston. April, 1977.*

Weiss, Iris R. *Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education*. March, 1978.*

Welch, Wayne W. *Booklet V*. "Science Education in Urbanville: A Case Study." April, 1977.*

***Available from Government Printing Office, Washington, D.C. 20402. Case Study booklets are not available singly from GPO. *Case Studies in Science Education*, Vol. I contains booklets 1-11, Vol. II contains booklets 12-18.**

The More Things Change:...
The Status of Social Studies

Gerald Ponder
Ron Brandt
Ben Ebersole

The past two decades have witnessed great changes in the public perception of social studies education. In the mid-1950s history and geography dominated a social studies curriculum intended by tacit assumption to produce "good citizens" literate in the heroes and landmarks of the past. But the remarkable curricular turmoil of the ensuing years produced a program in many ways typified by the much-debated *Man: A Course of Study.* Receiving much of its impetus from the National Science Foundation, the conglomerate of curriculum revisions that characterized the 1960s and early 1970s sought to move social education from social studies to social science. The social studies curriculum was to become organized by the concepts and principles that formed the structure of the scientific disciplines instead of the chronological organization of history. Rather than memorizing names and dates, students were to inquire into causality and develop their own generalizations from primary source material, from direct observation of social events and processes, and from games and simulations. For teachers, the focus was to shift from information to be delivered to questions to be asked and issues of personal values and social controversy to be raised. This indeed was to be a substantially different social science curriculum from that of past generations. Or so it was intended.

But the recently completed NSF study of the precollege social studies program says differently. Utilizing several major sources—an extensive literature survey, national surveys of offerings and practices, and a set of case studies of actual field sites—to triangulate their findings and support their conclusions, the NSF reports suggest strongly that little has changed since the 1950s. The impact of curriculum revision has been severely diluted by the daily demands of school business and the constraints of teaching in classrooms. The set of NSF reports offers far more than a summary judgment of the impact of curriculum revision, however. They are filled as well with the meat and flesh of important information and reasonable inference for those concerned with schooling, thus the National Science Foundation decided to disseminate these findings through the media of major national organizations, including ASCD. This article is part of that larger report to the ASCD membership and, like the other articles in this series, is organized into three major categories of content, method, and organization and support for purposes of clarity in presentation.

Content

The picture of the social studies curriculum that emerges from the NSF studies is one of breadth and diffusion in terms of content and goals. There is little agreement among classroom teachers or among advocates and analysts within the field as to what ends social studies education is to serve or the most appropriate subject matter to teach, a condition that prevents great internal integrity within the course offerings in schools and provides resistance to attempts to unify the social studies program or to articulate it with the rest of the school curriculum (Wiley & Race, 1977; Denny, 1977).[1] Further, the social studies curriculum in schools is still more social study than social science, with history and geography the dominant subjects (Weiss, 1978). Content selection in social studies courses is marked by a high degree of personalism, with considerable variation among individual teachers regarding the topics to be taught and the time allocated to each (Denny, 1977; Smith, 1977). In the elementary schools, the social studies receive little attention and, when they are taught, serve primarily as another opportunity to teach reading and writing skills. As one teacher in Fall River candidly reported, "We do social studies in the afternoon, when the kids are tired—if there's a chance" (Smith, 1977, p. 21).

At **all** levels, the social studies curriculum is a textbook curriculum. Teachers use the textbook to organize their courses and students encounter the content of those courses primarily through textbook pages. Completing worksheets and answering questions at the ends of the chapters are major classroom activities (Welch, 1977). Few teachers have even **heard** of approaches oriented toward the social sciences, and fewer still use them (Weiss, 1978; Wiley & Race, 1977). The "back-to-the-basics" movement has tended to strengthen the rationale for using textbooks to present factual information and deliver generalizations, consequently contributing to the weakening of problem-solving and analysis as legitimate curricular concerns in social studies education (Denny, 1977). Moreover, despite repeated cries in the literature for greater relevance in the social studies curriculum, content relevance is **not** a dominant theme among social studies teachers at any level. When such concerns occur, they tend to come from high school teachers who, more than any other group, see their role as preparing students for life after school (Denny, 1977; Smith, 1977). Students, in turn, view the social studies as an often interesting, but relatively unimportant area of the total curriculum. In the words of one eighth-grader, "Open space classrooms are ok in social studies class because you really don't have to concentrate there" (Denny, 1977, p. 52).

---

[1] Citations utilized in this report are primarily illustrative, to avoid the clutter of extensive lists of references. Similar statements and conclusions can be found in nearly all of the various studies.

Method

Despite extensive attention to the skills and strategies of inquiry teaching in the prescriptive literature, it is little used in social studies classrooms, and many teachers who tried inquiry-oriented approaches have abandoned them. This does not mean, however, that social studies instruction is characterized extensively by lecture, but rather that some kind of structured approach to the presentation of information (worksheets, textbook questions, recitation) does appear to be the order of the day (Denny, 1977; Welch, 1977). Where individual variability in teaching method occurs, it is most often found at the high school level, also the site of the most frequent use of inquiry methodologies and the materials of the national curriculum projects such as the High School Geography Project (Smith, 1977). Again, however, the back-to-basics movement has weakened efforts at promoting inquiry and problems analysis. This condition is exacerbated by the paucity of clear and rigorously derived information on the learning outcomes produced by inquiry and the scant attention in the research literature to the actual operation of inquiry in classroom settings (Denny, 1977; Wiley & Race, 1977).

Organization and Support

The picture of organization and support systems drawn by the NSF reports is one of disparity between the demands of running a school district and those of providing schooling in classrooms. Mary Lou Smith summarily described these different demands by writing:

> *The administration of the district travels in an uneasy orbit held in place by the centripetal forces of attempted centralization of management and curriculum coordination and the centrifugal forces of territoriality and building autonomy* (Smith, 1977, pp. 2-3).

The spread of social studies content through a variety of seemingly bounded disciplines has hindered attempts by school systems to control the curriculum through statements of objectives and blocked significant efforts at articulation. Moreover, the factors of personalism and particularism that characterize teachers' content selection and methodology also mark their preferences for organizational patterns and support services. And these differences are reinforced by the discrepancy between district-level needs and classroom needs. For example, while district administrators often view social studies classes as places to mediate the social effects of ability grouping in other curricular areas, social studies teachers typically support grouping as a means to decrease the wide range of interests and abilities they must face (Denny, 1977). Further, teachers report their greatest support need to be for supplementary materials and resources more closely matched to their students' reading abilities than the textbook. And these teachers want to be able to choose the materials they need themselves. Yet social studies is the curriculum area least likely to have its own district-level coordinator to help locate resource materials, and it is one of the first areas to be affected by budget cuts (Welch, 1977). Thus teachers complain of a lack of adequate assistance in learning about available materials and a lack of funds to purchase them, once they are known.

Interpretations

The picture that emerges from these National Science Foundation reports—a picture drawn in especially telling fashion in the case studies—is one of minimal impact by curriculum revision due to the extraordinary social complexity of schools and systems. This picture may be most interpretable by adopting the perspective implied by Smith (1977) of separate "orbits" or environments, each with its own peculiar set of demands and intentions that resist interaction. From this perspective, the curriculum reform movement of the 1960s can be seen functionally as an effort to produce the kind of social studies curriculum that scholars at the university level believed was needed.

District-level administrators, on the other hand, have little commitment to the self-images of the academic community. Instead, their major concerns are those of responsiveness to the public, as represented by lay boards of control, while providing at least the appearance of being in control of their system. These demands have led to great efforts to produce manageable organizations while responding to recent public demands for accountability. Thus curriculum directors and supervisors have had little direct contact with teachers other than to exhort them to produce curriculum guides filled with measurable objectives for public consumption.

The world of the classroom, in turn, is distinctly different both from academe and the central office. Teachers face daily the task of meeting with relatively large numbers of students, diverse in their abilities and inclinations to do school work, over fairly long periods of time. Moreover, that time must be filled with educationally justifiable activities. Classrooms are thus characterized by the demands of immediacy and complexity as well as the task of maintaining cooperation to "get through the day" (Doyle, 1978; Dreeben, 1973). Thus teachers are most concerned about their own particular problems, they wish to choose materials and resources that meet their needs, and they tend to stamp content and method with their personal marks to allow them to maximize control of their environment. Methods that increase the complexity of this environment, such as inquiry, are seldom used, and then largely with more cooperative (more able and more interested) students. Since the essential structure of this environment has not changed in the past twenty years, teaching practices have not changed and change efforts are resisted because of their lack of congruence with teachers' perceptions of the most practical and workable methods in their own particular classrooms.

The weight of evidence and inference contained in the NSF status reports and case studies suggests strongly that our notions about the efficacy of curriculum revision need restructuring. We have too long sought change through curriculum revision without understanding the environmental forces that press for stability and continuity by resisting the processes of curriculum implementation. It seems time to ask why things occur as they do in social studies classrooms.

References

Denny, T. *Some Still Do: River Acres, Texas.* Washington, D.C.: National Science Foundation, 1977.

Doyle, W. *Student Management of Task Structures in Classrooms.* Paper prepared for the Conference on Teacher and Pupil Strategies, St. Hilda's College, Oxford, England, September 1978b.

Dreeben, R. The School as a Workplace. In R.M.W. Travers (Ed.), *Second Handbook of Research on Teaching.* Chicago: Rand McNally, 1973.

Smith, M. L. *Teaching and Science Education in Fall River.* Washington, D.C.: National Science Foundation, 1977.

Weiss, I. R. *Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education: Final Report (Rpt. No. RTI/1266/06-01F).* Research Triangle Park, N.C.: Center for Educational Research and Evaluation, 1978.

Welch, W. W. *Science Education in Urbanville: A Case Study.* Washington, D.C.: National Science Foundation, 1977.

Wiley, K. B. and Race, J. *The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975, Volume III: Social Science Education.* Washington, D.C.: National Science Foundation, 1977.

What it All Means

Implications of the National Science Foundation Reports on the Status of Science, Mathematics, and Social Studies Education

Ron Brandt and Other Members of the ASCD Dissemination Team[1]

This is the last in a series of articles in which an ASCD team has summarized findings of a major study sponsored by the National Science Foundation (NSF). Composed of a survey, three literature reviews, and a set of case studies, the NSF reports are a thorough assessment of the status of science, mathematics, and social studies education in elementary and secondary schools.

Instructional Materials

A recurring theme throughout the reports is the prominence of textbooks as the basis for much of the curriculum that is actually taught in science, social studies, and mathematics classrooms (Helgeson and others, 1978; Stake and Easley, 1978, Vol. II, p. 15-5; Weiss, 1978, p. 102; Wiley and Race, 1977, p. 79). Some of the materials produced with NSF sponsorship are well accepted; for example, BSCS biology is used in about 40 percent of schools (Helgeson and others, p. 26). Most NSF materials, however, are not widely used (Wiley and Race, p. 323).

Some might say that NSF programs are resisted because the assumption on which they are based—that developers can create programs for others to "implement"—is mistaken. According to this view, teachers must be involved in developing their own curriculum, and the low usage rate of NSF-sponsored materials proves they will not use curricula planned by others.

That teachers must be involved in curriculum planning is almost beyond dispute in ASCD circles. However, the notion that development must be done at the local level does not square with findings of the reports that teachers use textbooks (which are not locally designed) as the basis for their curriculum.

Most teachers will probably continue to plan their instruction around materials produced by others. What they want are materials which they consider usable in every sense—academically sound but practical, suitable for students with varying backgrounds and abilities, and adaptable to a variety of purposes and circumstances. They will reject materials which seem to be too unconventional, too scholarly, or too complicated.

DEVELOPMENT OF MATERIALS

For the foreseeable future, it would seem appropriate for ASCD members to do whatever they can to encourage development of high quality materials. Should federal agencies, such as NSF, be involved? That is a matter on which reasonable people differ. Most local and state governments are not in a position to publish textbooks, and commercial publishers apparently cannot afford to develop high-risk materials or do the extensive field testing which is often needed. For these reasons, we feel that the federal government can make a contribution without necessarily establishing a national curriculum.

A reasonable guideline for federal agencies may be the one established by the National Institute of Education after a thorough airing of the question: create curriculum materials only if a clear national need exists which apparently will not be satisfied any other way, and then mostly to encourage further work by others—by conducting and disseminating applied research, testing new approaches, creating prototypes, etc. (Schaffarzick and Sykes, 1978).

CURRICULUM CONTENT

An important function served by NSF projects was to raise serious questions about the content of the curriculum: what students should learn. Those questions must continue to be asked—and answered. Otherwise, whatever was taught yesterday will continue to be taught tomorrow. No school or district, no state, no publisher—would dare try to change it singlehandedly.

In some countries, a national curriculum center is responsible for revising the curriculum periodically. For example, a revised physics curriculum was installed a few years ago throughout the Soviet Union. New textbooks were published and all teachers were trained to use them.

Americans dislike the idea of a national curriculum, because we are so firmly committed to local control of education. How then, will substantive curriculum change come about?

One way would be for agencies or organizations with national influence, such as NSF, to organize a process by which the essentials of a given course, or subject area, or even the entire curriculum, would be redefined. The result would be not a finished course or textbook, but a syllabus suggesting what should be taught.[1] We will not attempt to say exactly how this should be done, or who should do it. We will only point out that it needs doing.

---

[1] Benjamin Ebersole, Baltimore County (Maryland) Schools; Thomas Gibney, University of Toledo (Ohio); Edward Karns, Parma (Ohio) Public Schools; Ruth Long, ASCD Associate Director; Gerald Ponder, North Texas State University, Denton; Ronald Stodghill, St. Louis (Missouri) Public Schools; and Robert Yager, University of Iowa.

THE TEXTBOOK DEVELOPMENT PROCESS

Because textbooks will almost certainly continue to be an important influence on what is actually taught, educators should examine carefully the processes by which textbooks and teachers' manuals are developed, selected, and used. In many cases, commercial materials may be produced without involvement of classroom teachers (which most NSF materials had) and with little or no field testing before they are marketed. As the major professional association concerned with curriculum and instruction in elementary and secondary schools, ASCD should search for ways to help improve the development process.

EVALUATION OF MATERIALS

A related issue is that of evaluation. Some NSF materials may have been rejected not because teachers failed to recognize their merits, but because they were in fact faulty. Teachers who stopped using some of the materials complained they were too rigid, too difficult, and too abstract for many students (Helgeson and others, p. 181). If that is true, why were such criticisms not resolved when the materials were field-tested? The answer is complex, of course. For one thing, times have changed. In the 1960s, national opinion supported education of a scientific elite. The emphasis now is more on basic skills and equality of opportunity.

We may observe, however, that developers who evaluate their own products find it difficult to be objective. Materials developed in the future, no matter who develops them, should be evaluated by an independent party. Such an agency should take seriously the concerns of teachers for whom the materials are intended and should collect extensive data from teachers and students in a variety of circumstances.

Teacher Education and Support

A second major concern is that existing organizational arrangements frequently do not provide for the support that teachers need and want. For example, very few school districts have full-time coordinators (Weiss, p. 39). Nearly half of all teachers report they do not receive adequate assistance in learning about new teaching methods and instructional materials. Add the fact that teachers are not always well prepared academically (Wiley and Race, p. 143) and it becomes evident that something more is needed.

Of course, there is no consensus among educators as to exactly **what** is needed. Some would have more specialists, such as assistant principals, curriculum directors and general supervisors. Still others would opt for teacher centers and other ways by which practicing teachers can help one another. All these may be desirable, but tightened school budgets will probably result in fewer, rather than more, of any of them.

SCHOOL SYSTEM ORGANIZATION

Fortunately, ASCD is launching a major study of school organization. The project team, to be headed by Charles A. Reavis of Texas Tech University, is charged with analyzing the impact of recent developments—including decentralization, collective bargaining, management studies, encroachments on principals' time, and declining revenues— on provision of supervisory services. Their report could contribute to a needed redefinition of middle management roles in education.

CONTINUING EDUCATION OF TEACHERS

Another need is for mechanisms which insure that teachers have opportunities for continuing education. NSF institutes, although they were intended primarily as a means for updating teachers' knowledge of their subjects, did much to promote teacher-teacher and teacher-scientist exchanges. Such national efforts should be continued and expanded.

Knowledge

Perhaps what is needed most of all is knowledge about teaching and learning. Those who have read our summaries—or better yet the reports themselves—know that they tell us very little of what we need to know. In fact, their most important contribution may be to clarify what we do not know for sure.

For example, Wiley and Race say there is almost no documentation about what actually goes on in classrooms and consequently how that may or may not have changed over time (p. 77). Teachers report using inquiry methods but one cannot be certain about what they mean by that (p. 73). Available research provides no help in determining the kind of content which would best achieve the goals of social studies (p. 168). People do not even agree about what the field of social studies is, or what its goals are supposed to be (pp. 275-77).

---

[1] For an example, see *Master Curriculum Guide in Economics for the Nation's Schools, Part 1: A Framework for Teaching Economics.* New York: Joint Council on Economic Education, 1977.

Under the circumstances, we believe educators concerned with supervision and curriculum development should shift their focus from speculation and advocacy to a greater emphasis on understanding. Questions formerly asked in prescriptive terms (what should be done?) might be more productively couched in descriptive and analytical terms (what is happening here and why is it happening?), at least as a first step. Such an approach will delay the rush to "improve," to be sure, but it offers the possibility of increasing the long-term impact of change efforts.

POINTS OF VIEW

One matter requiring more thorough study is that of varying "orbits" (Smith in Stake and Easley, 1978; also see article in this series by Ponder, pp. 6-8). Members of various groups, such as college professors, central office administrators, and principals hold views about content and methods of teaching influenced by their positions. There seem to be major differences in orientation between classroom teachers and many of those who are supposed to help them do a better job. That can be troublesome if they do not agree about what is better and what is not. For example, the curriculum developers sponsored by NSF apparently held views about the kinds of materials needed that differed from the perceptions of many of the teachers who were expected to use them. If similar efforts are to be more successful in the future, such differences must be understood and moderated.

THE CHANGE PROCESS

Another matter which should be better understood is the change process in schools. Not only should researchers continue to investigate the factors associated with successful and unsuccessful change efforts, but administrators should learn to use the findings in managing change.

An approach which would seem to be especially fruitful is to focus investigation on the sites where changes have been implemented successfully in order to find out why. What accounts for the fact that some teachers **are** using inquiry processes and NSF materials? An example of this approach is a recent study by the Rand Corporation (Berman and McLaughlin, 1978) in which several elements of an effective change strategy are identified (pp. 22-34).

An obvious hypothesis is that too many administrators have underestimated the difficulty and complexity of change. Even such a straightforward change as the introduction of new instructional materials must be carefully managed and supported, particularly when the materials differ substantially from familiar ones. Change is not a matter of simply selecting a new program and "plugging it in."

EFFECT OF PRACTICES

We also need better information about the effects of various practices and programs. Of course, much of the research and evaluation conducted in education is designed to produce that very thing. It is all the more discouraging, then, to find that a careful review of research literature tells us that little can be said with assurance about the effectiveness of various methods. Our nation needs more well-qualified researchers who have the facilities and financial support necessary to investigate important educational problems. At present, much of the research in education is done by graduate students and other individuals working with very limited resources. Problems tend to be defined so that they are manageable. The result is that:

"*. . . a large proportion of the effectiveness research . . . falls under the heading of instructional methods and much of this focuses on various methods labelled 'critical thinking,' 'inquiry,' and the like. Most of this research shows no significant differences between 'critical thinking' methods and so-called traditional methods; however, weaknesses in research design and weaknesses in attempts at interpreting existing research may well be hiding real differences in effectiveness*" (Wiley and Race, p. 9).

The fact that there has been little research on learner variables (Wiley and Race, p. 204) suggests that researchers should stop trying to prove that "critical thinking" is superior to "traditional" teaching and start trying to find out **what** practices are effective with **what** students for **what** purpose under **what** conditions.

Our limited knowledge puts us in an awkward position. As honest professionals, we must concede those limits. At the same time, however, we must continue to act. Many of us have supported practices such as teaching for inquiry, even though we could not prove their superiority. Were we wrong to commit ourselves? Should we have remained neutral until we had better evidence? Probably not. We have a right to our convictions; indeed, we have a responsibility to encourage what we believe is good education.

Nevertheless, all those interested in what schools are doing (and that seems to include a lot of people these days) should exhibit greater respect for evidence and less inclination to rely on their own prejudices. We have enough charges, countercharges, blaming and quarrelling already. We need more understanding as the basis for real improvement.

Summary

In summary, based on findings of the NSF studies, we see a need for:

INSTRUCTIONAL MATERIALS

1. Continued development of high quality instructional materials, with federal sponsorship if necessary.

2. Procedures for periodically redefining what students should learn.

3. A thorough examination of the processes by which textbooks and teachers' manuals are developed, selected and used—so that they may be improved.

4. Objective evaluation of instructional materials.

TEACHER EDUCATION AND SUPPORT

1. Redefinition of middle management roles to provide more adequate staff development and support for teachers.

2. Mechanisms, such as NSF institutes, to provide for continuing education of teachers.

KNOWLEDGE

1. Knowledge about differences in points of view between teachers and other educators.

2. Knowledge about the change process in schools.

3. Knowledge about effects of various practices and programs.

References

Berman, P., and McLaughlin, M. W. *Federal Programs Supporting Educational Change*. Vol. VIII: Implementing and Sustaining Innovations (R-1589/8-HEW). Santa Monica, California: The Rand Corporation, 1978.

Helgeson, S. L., Blosser, P. E., and Howe, R. W. *Science Education*. Vol. 1 of The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Washington, D.C.: U.S. Government Printing Office, 1978.

Schaffarzick, J., and Sykes, G. "A Changing N.I.E.: New Leadership, a New Climate." *Educational Leadership*. 35: 367-372. 1978.

Stake, R. E., and Easley, J. A., Jr. *The Case Reports*. Vol. 1 of Case Studies in Science Education. Washington, D.C.: U.S. Government Printing Office, 1978.

Stake, R. E., and Easley, J. A., Jr. *Design, Overview, and General Findings*. Vol. 2 of Case Studies in Science Education. Washington, D.C.: U.S. Government Printing Office, 1978.

Suydam, M. N., and Osborne, A. *Mathematics Education*. Vol. 2 of The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Washington, D.C.: U.S. Government Printing Office, 1978.

Weiss, I. R. *Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education*. Washington, D.C.: U.S. Government Printing Office, 1978.

Wiley, K. B., with Race, J. *Social Science Education*. Vol. 3 of The Status of Pre-College Science, Mathematics, and Social Science Education. Washington, D.C.: U.S. Government Printing Office, 1978.

best copy available

Report of the Curriculum Review Committee, Commission on Education

James C. Clark*

Section I—Background

During 1976-77, the National Science Foundation (NSF) undertook a comprehensive study of science, mathematics, and social studies education in elementary and secondary schools. The seven volumes resulting from this research are: *Case Studies in Science Education* (2 volumes); *Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education* (1 volume); *The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-75* (3 volumes); and *An Overview and Summaries of Three Studies* (1 volume). These materials are described in detail in Appendix A of this report.

In order to disseminate their findings, the NSF invited nine national organizations to review and interpret the NSF status studies in science education for their respective memberships. These organizations are:

- American Association for the Advancement of Science
- American Association of School Administrators
- Association for Supervision and Curriculum Development
- National Academy of Science
- National Congress of Parents and Teachers
- National Council for Social Studies
- National Council of Teachers of Mathematics
- National School Boards Association
- National Science Teachers Association

The purpose of this dissemination effort is to provide timely material for key people and organizations who can use this information for investigation and improvement of curriculum at the local, state and national levels. Of all organizations invited to participate, the National PTA is the only one which represents parents and students. For this reason, the PTA's contribution to the project is vitally important.

This report presents to the PTA membership an interpretation of the NSF status studies of science education, with recommendations for actions that PTA members can take to improve the teaching of science, mathematics, and social studies in their schools.

The National Science Foundation

The National Science Foundation is an agency of the federal government established in 1950 to promote and advance scientific progress in the United States.

One of the NSF's most important functions is to develop and help implement science education programs that can better prepare the United States for meeting the challenge of the decades ahead. NSF educational programs are aimed at increasing understanding of science at all educational levels and an adequate supply of scientists and engineers to meet our country's needs.

As part of its mandate to improve the nation's science education, the NSF has developed a variety of curriculum materials which are in use in U.S. schools. The NSF also has developed and conducted numerous teacher training programs.

After 20 years of efforts to improve instruction in mathematics and the natural, physical and social sciences, the NSF decided to determine the current status of education in those subject areas. The NSF status studies in science education were aimed at developing a picture of science, mathematics and social studies teaching in elementary and secondary schools today, so that educators, policy makers, parents, students, and other concerned citizens will have the knowledge they need to meet our society's future educational needs.

---

*On behalf of the Curriculum Review Committee.

This report was published by the National Congress of Parents and Teachers, National PTA, Chicago, Illinois. Appendix B was published as a separate brochure, "A Question for Parents: How Good is the Curriculum in Your School?"

The National PTA

When proclaiming American Education Week in November, 1957, the President of the United States called on local school boards and parent-teacher associations "to scrutinize your school's curriculum and standards to see whether they meet the stern demands of the era we are entering."

The National PTA responded by publishing a handbook on school-improvement studies, *Looking In On Your School: Questions to Guide PTA Fact Finders,* and by requesting information from state presidents on PTA participation in curriculum planning. In 1963, the National Board adopted a statement in which citizens were urged to be aware of the need for a "balanced curriculum in their schools," and parents, educators and all other citizens were encouraged to support continuing review of curriculums to assure that they reflect advances in knowledge and are suited to a complex, rapidly changing world.

The PTA Action Program, *Quality Living and Quality Learning for all Americans,* published in 1970, included emphasis on "Changes and Innovations to make the curriculum relevant and challenging for all students."

Over the years, the organization's journals—*The PTA Magazine* and now *PTA Today*—have kept readers informed about education in a changing society, and current thinking on the issues. Typical articles have included, "What's New In Curriculum?," "Curriculum Planners Are Doing Their Thing," and "Diversified Studies for Diversified Students."

The National PTA's Commission on Education acts as a clearinghouse for curriculum information, seeking to keep abreast of trends in education, and encouraging PTA units to take action in events that shape the course of education in the local school community, and in the state and nation.

The Curriculum Review Committee

Aware of the National PTA's long-standing interest in curriculum development in the nation's elementary and secondary schools, the National Science Foundation asked the PTA to interpret and disseminate its status studies of science, mathematics, and social studies education for PTA membership. Funding for the work was provided by a grant given to the National PTA by the NSF.

Review of the NSF status studies was part of the work of the Commission on Education of the National PTA. An ad hoc committee—the Curriculum Review Committee—was appointed by the Commission to interpret the NSF materials for PTA membership.

In addition, three consultants from the Chicago Board of Education provided professional input and guidance with regard to the subject areas of science, mathematics and social studies.

This report represents the efforts of the Curriculum Review Committee to provide PTA members with an overview of the NSF status studies. The findings, conclusions and recommendations of the Curriculum Review Committee are based on the NSF status studies and are designed to encourage PTA members' involvement in curriculum. Moreover, the most pressing curriculum related issues in the NSF status studies for PTA membership, as discerned by the committee, are itemized and commented upon. These issues include "teacher issues" (i.e. preservice, inservice, methodology), "student issues" (i.e. tracking, individualized instruction, competency based education), and "administrator issues" (i.e. curriculum supervisors, principals, articulation, consolidation). It is important to note here that the various curriculum issues are so classified only for the purpose of presenting information in the context of this report. Presumably, all of the issues discussed affect teachers, students **and** administrators; the Curriculum Review Committee felt that separating out issues and grouping them would enable PTA members to better grasp the complexity of curriculum considerations. Finally, this report suggests actions for PTA parents who want to become involved in these issues, including specific questions parents can ask about each of the three subject areas.

Section II—Problems and Issues

The main body of this report, "Problems and Issues," highlights those issues in the NSF status studies in science education that the Curriculum Review Committee felt were most important for PTA members to understand and act upon. Each subsection contains citations from the NSF status studies, the Curriculum Review Committee's opinions about the issue, and suggestions for questions that parents can ask or actions PTA members might take.

Teacher Issues

Preservice Teacher Training. *"Preservice Teacher Training" refers to the process of educating students to become teachers. Usually, this involves students in*

4-year colleges of education within universities, state teachers colleges and other institutions which provide professional training for certification to teach in public schools.

The NSF Survey reveals that "sizable numbers of teachers have earned one or more degrees beyond the bachelors; secondary teachers are significantly more likely than elementary teachers to have earned a graduate degree. In addition, many teachers have taken courses for college credit in recent years . . ."[1] This statement is further substantiated in the mathematics status report: "The mathematical background of students completing preservice programs for elementary- and secondary-school teaching has increased significantly during the twenty-year period (1955-1975) . . . Teachers are acquiring a second professional degree in greater percentages and at an earlier age than ever before." [2]

Unfortunately, no relationship could be shown between a teacher's educational background and student performance. In other words, possession of an advanced degree by a teacher does not mean that his or her students will perform better than the students of a teacher holding only a bachelor's degree.

Further, despite the increased number of teachers with advanced degrees, there is evidence that prospective teachers are not getting enough training in methodology. "(T)he science education literature does not indicate that colleges and universities have programs specifically designed to prepare science teachers to work with junior high or middle school pupils." [3] "Science courses taken to fulfill a general education requirement are likely to be of the survey type or a relatively basic introduction to a particular branch of science. These courses are not likely to contain an emphasis on science process skills stressed in a science methods course." [4]

Similarly, inadequacies in preservice teacher education may extend to a lack of training in a variety of methods of "getting to" students who do not respond to a standardized, programmed classroom approach.

These inadequacies in teacher training may be addressed in the following ways:

- Increased emphasis on creative teaching methods should become a part of methodology courses;
- Instructors in teachers colleges can spend more time in the field, in both rural and urban classrooms, so that they can transmit to education students what is actually happening in real-world schools;
- Early teaching experience in teacher training programs is highly desirable.

The most significant trend in teacher education at the preservice level is the move toward incorporating pre-student-teaching field experience in mathematics education . . . There is a significant trend toward including laboratory or activity learning emphases in both the mathematics and methodological phases of prospective elementary teachers' academic preparation for teaching. [5]

Although some actions are being taken to improve teacher training, there is an effect PTA members can have. PTA units can urge that representatives of teachers colleges be appointed to inservice training committees within districts. In this way, professionals from institutions of higher education can learn first-hand of the needs and problems of teachers and take this knowledge back to their schools and see that it gets into teacher-training courses.

Inservice Teacher Training. *"Inservice" refers to the continuing professional support activities provided for teachers who are already employed as classroom teachers. Inservice training may be directed toward many different objectives including: (1) a resource for addressing an individual teacher's strengths and weaknesses; (2) an up-date on current subject area materials and how to use them; (3) a training course for teachers geared to a specific problem, such as including handicapped children in regular classes ("mainstreaming").*

In 1967, the U. S. Office of Education issued a call for proposals involving the development of comprehensive undergraduate and inservice teacher education programs for elementary teachers . . . A search and review of the science education literature related to program description did not reveal any noticeable impact of these model programs on elementary science teacher education.[6]

Research provides little evidence that participation in the inservice education improves the effectiveness of teachers.[7]

From 1965 to 1975, the National Science Foundation spent $37 million developing and conducting inservice training programs in science and mathematics. Yet, from the above quotes, there appears to be a very real question as to the value of those programs.

More research needs to be done to determine why inservice programs seem to be ineffective in improving the quality of instruction offered by teachers, and how such programs can be improved. To the extent that NSF model programs have not been successful, part of the problem may lie in their generalized nature which diffuses their impact. Teachers may not find that the information they are getting from nationwide model inservice program is relevant to their special needs in their particular schools. It may also be that these programs are not getting to the teachers who need them most. Observers have noted heavy participation in NSF inservice training by highly motivated, highly skilled teachers who presumably have less need for such programs.

Teachers continually express the need for good inservice training. "Teachers want inservice education and prefer that it be related to programmatic and instructional needs in their schools."[8] "Although secondary school science teachers are currently younger and better educated than in the 1950's, there is still a critical need for inservice training, both as perceived by the teachers, and as indicated by the research . . . "[9]

The quality of inservice education depends on efforts at the local level. "Leadership for inservice education at the local school level can appreciably change the character of inservice education . . . "[10]

PTA members can find out if their school districts have inservice training committees. Membership on inservice committees should include not only professionals from the education community, but parents, students, and members of the community at large who may have important ideas to share and be able to identify educational needs. Inservice programs must be designed to meet the needs of a specific school or district.

Good inservice education might help solve another problem, that of teacher "burn-out." In Case Study #3, teachers in an affluent suburban school in the Midwest felt they were going stale despite the fact that they had large budgets, creative teaching opportunities, and intelligent, highly motivated students. Teachers "going stale" could benefit from new ideas and techniques they might obtain from inservice programs.

Mixed elementary and high school inservice programs should be investigated. Teachers at all levels have the same basic problem of motivating students, and an exchange of ideas and techniques from different grade levels could prove useful. Such mixed inservice training might also help break down barriers that often exist between elementary and secondary teachers and thus facilitate articulation. (See pg. 14)

The NSF status studies also revealed that teacher training, both preservice and inservice, must prepare teachers to handle multi-cultural, multi-ethnic, and multi-racial situations. The United States has great cultural, ethnic, and racial diversity, and even though teachers may be operating in a mono-cultural situation, or teaching students of a single race, they need to have a broad perspective and understanding of other cultures and races.

Programs designed to "mainstream" children with learning disabilities and other problems are presenting difficulties that inservice training can help alleviate. Teachers need inservice instruction on how to cope with mainstreamed children. And since mainstreaming programs are federally mandated, a realistic allocation of federal funds is needed for such training, as well as for additional facilities and personnel.

Discovery and Learning. *"Discovery and Learning" or "inquiry method" refers to a type of instruction. This method is applicable to all three subject areas. Essentially, this approach seeks to involve children in "learning by doing," as opposed to a rote or "lecture-based" curriculum. All three consultants to the Curriculum Review Committee endorse the "discovery and learning" method and encourage its use in their own in-service sessions.*

One of the more important findings of this case study project was that, despite considerable contact with legacies of NSF-sponsored curriculum projects and with in-service programs dedicated to the promotion of student inquiry, very little inquiry teaching was occurring in science, math, and social studies in the eleven states.[11]

Lectures are used quite frequently in science, mathematics and social studies classes . . . Class discussions occur on a daily basis in 50 percent of science classes, 61 percent of social studies classes, and 71 percent of mathematics classes . . .[12]

Hands-on experiences are relatively infrequent in social studies classes; 34 percent . . . never have students working with manipulative materials, while another 24 percent do so less than once a month . . . Many mathematics classes make use of hands-on materials . . . The use of manipulatives is significantly more common in science classes . . . Simulations *(role-play, debate, panels) . . . are significantly more common in social studies classes than in science or mathematics classes . . .* [13]

Various "discovery" approaches to learning are in use, but their employment seems to be spotty. The authors of the NSF case study reports suggest that the inquiry approach and other teaching techniques which depart from a textbook- or lecture-based curriculum are given more lip service than use. They also indicate that parents prefer a more traditionally fact-based curriculum which will equip their children with the tools they need to get into college or find a job after graduating from high school.

In the Polin survey, parents were asked, "Which of the following do you expect a teacher to impart to your children?" Eighty-three percent of respondents stated that it was important for teachers to impart to their children an "interest in discovery and learning." This was the highest ranking response, ahead of specific math and language skill acquisition.

An interest in discovery and learning, and use of inquiry and hands-on techniques and laboratory work need not conflict with acquisition of skills and facts. But if an inquiry-based curriculum is to succeed, teachers must be given support. They must know that the community stands behind them. They must have access to training in inquiry and other new teaching approaches, staff support, and proper materials.

Overall, 61 percent of science, mathematics and social studies teachers indicated a need for assistance in learning new teaching methods; 43 percent currently are not receiving such assistance . . . Fewer than half of all science, mathematics and social studies teachers feel they are competent in (the discovery or inquiry approach) without assistance . . . 48 percent of all science, mathematics and social studies teachers indicated they would like assistance in the use of manipulatives, while only 14 percent feel they are receiving an adequate level of assistance in this area . . . [14]

Perceived barriers to science teaching in the elementary schools include:

1. Lack of consultant services; 2. Lack of supplies; 3. Lack of room facilities; 4. Insufficient funds; 5. Lack of sufficient knowledge; 6. Lack of inservice opportunities; 7. Teachers cannot improvise; and 8. Teachers are not familiar with methods. [15]

With regard to instructional materials, the case study authors noted that " . . . instructional materials were budgetarily trivial . . . But the recent EPIE survey revealed that these monetarily trivial, topically dull things were crucial to science instructors in the U.S. Over 90 percent of science teachers in a sample of over 12,000 teachers said their instructional materials were the **heart** of their teaching curriculum 90-95 percent of the time . . . The curriculum did not venture beyond the boundaries set by the instructional materials." [16]

Quite obviously, the instructional materials available to a given class, and the use made of them play a crucial role in determining the curriculum, as well as influencing to a great extent the quality of instruction.

Inadequate facilities appears to be only a minor problem in mathematics and social studies . . . The situation in science, on the other hand, is perceived as considerably more problematical . . . Insufficient funds for purchasing equipment and supplies is considered a problem in all three subject areas . . . [17]

The availability of laboratory assistants or paraprofessional help is a major problem, with teachers of 58 percent of science classes rating this factor as 'important, needed.'" Science supplies are also considered inadequate by many teachers . . . 53 percent indicate that money to buy supplies on a day-to-day basis needs improvement . . . [18]

The general pattern by type of community is one in which suburban schools are the best equipped, followed by urban schools. Schools in small cities and rural areas are the least well equipped . . . [19]

The problem of inadequate supplies is not confined to rural or small school systems, though it is most acute in them because of a lack of discretionary funds for necessary enrichment materials. However, there are many imaginative ways in which teachers can develop teaching aids and materials at low cost, such as a project in which students build hand lenses for a few cents apiece and then use them to investigate the real world. A "hands-on" approach may be something as simple and inexpensive as bringing caterpillars into the classroom to teach metamorphosis, rather than teaching the subject out of a textbook.

There is a substantial amount of available material on practical ways to teach science with inexpensive, hands-on materials, and new ideas for teaching science outside the textbook. School systems need to make the fullest possible use of such materials and techniques, either by establishing science resource centers, or by setting up an information bank to let teachers know what is available. It hardly needs to be said that the PTA can play an important role in projects of this kind.

There is often institutional resistance to the purchase of professionally prepared science materials. One example is SCIS, the Science Curriculum Improvement Study, a highly recommended package of science materials. Teachers want it and use it, but administrators resist making the expenditure, though they may spend a much larger amount per student on reading enrichment packages. Often the problem isn't the initial expenditure but teaching teachers how to manage the equipment so it can be used again and again and thus pay for itself over time.

NSF-prepared materials are available, but in many cases local schools just aren't aware of their availability. It has been suggested that NSF instruct state science and mathematics supervisors in the use of such packages so the supervisors can then go home and spread the word.

Both preservice and inservice training must be improved to provide more instruction in how to translate the textbook curriculum into a hands-on curriculum, how to use the world outside the school as a laboratory, and how to use real-life situations in a meaningful way in the classroom.

Parents can provide the impetus for broader use of inquiry and hands-on teaching by asking how much of it is done in their schools, and by encouraging programs to train teachers in alternative teaching methods.

Local PTA units also can inquire about the availability and use of instructional materials in their schools. Are adequate materials available? Are they being used, or do they sit in a closet somewhere? Are only "trivial" amounts of money being spent on instructional materials, and do budgets contain enough money to purchase the materials that teachers need?

Student Issues

Tracking, Grouping and Heterogeneous Classes. *All three terms refer to assignment of students to classes, separating or mixing them according to academic ability. While teachers and administrators decide how students are assigned to classes, the Curriculum Review Committee listed this issue as the first "student issue" because of its direct impact upon the student's learning environment.*

When educators speak of tracking, they usually mean the assignment of students into groups to be taught with different long-term objectives in mind, with lessons to differ usually in complexity and comprehensibility of the subject matter . . . Grouping is a term used (often in contrast to tracking) to indicate temporary assignment to learning groups to facilitate study toward common objectives . . . As it usually works out, homogeneous learning groups do differ with regard to the pace of learning, with regard to the enrichment or breadth of learning, and it is rare in most classrooms for a student to move from a slower group to a faster group. Yet homogeneous grouping is the best hope that educators have to come up with for the problem of providing (at minimum cost) good learning experiences for children in heterogeneous classes. [20]

Tracking was found to be pervasive in Case Study #1, a school system in suburban Houston. Decisions on whether or not a student is college material and which career fields students should pursue are made early, generally by ninth grade; and then students are tracked into a course of study based on those decisions. The decisions apparently come from counselors or advisors and result from test scores, with very little, if any, consultation with parents, teachers and students.

Although tracking and grouping may have certain benefits, they should not be used as an excuse to lock students into castes, slots, and categories, thus eroding their motivation to excel.

At the same time, there are very real difficulties in trying to teach large numbers of students whose capabilities and interests are widely divergent. An example is provided by Case Study #9, a school system in an eastern seaboard city, in which the courts have ruled against the grouping of students by ability. Since extremely diverse students are thrown together in a single classroom, discipline becomes a problem and little effective teaching gets done.

If it appears that tracking and grouping or heterogeneous classes are creating problems for students, parents can find out how the curriculum is or is not being adapted to these conditions; whether or not paraprofessionals and teachers aides are being used to help alleviate problems; and whether or not individualized instruction programs can be of any help.

Individualized Instruction. *"Individualized Instruction" refers to tailoring a course of study for each individual student based on his/her needs and abilities. This is usually based on a combination of specially designed instructional materials and teacher method.*

Individualized instruction would seem to hold promise for more effective teaching of a highly heterogeneous student body. For example, "science offers a high potential for a laboratory-oriented, student-centered learning activity which can be utilized for increasing individualization of instruction (but) . . . It appears that care will be necessary to provide for alternative approaches to competency if science instruction is to be individualized." [21]

In none of the case studies was there evidence of any fully developed instruction program; however, an Individualized Education Program (IEP) has been mandated by the state of Utah. The IEP requires schools to give each student from seventh grade on a specific, individualized course of study if the student so desires. A career interest to guide the student's program is identified from the seventh grade, but it can be changed. Once a year the student reviews his or her progress with parents, teachers and advisers so adjustments can be made. The IEP program is popular but slow in being implemented because of a shortage of personnel and money.

It's important to note that individualized instruction is not a panacea. "There is little evidence that self-paced programs for individualized instruction are any more effective than 'traditional' instruction; most low-ability pupils find it difficult to function using self-paced programs." Gifted students may benefit more from such programs, and there is evidence that "The needs of the talented are not being well served in the 1970s. Enrichment programs are especially needed for those in small schools." [22]

Individualized instruction and enrichment programs can serve useful purposes under certain circumstances. Perhaps the Utah program (as well as any other states or districts around the nation with IEP's) would be a valuable source of information for concerned parents who would like to see good IEP's in their schools.

Alternative Schools. *"Alternative Schools" refers in this section to physically separate institutions designed for students who have discipline or attitude problems with conventional schools. While the Curriculum Review Committee recognizes the needs of children in such schools, they felt that, ideally, conventional schools would strive to meet all students needs, thus eradicating the need for alternative schools.*

The concept of individualized education is carried to something of an extreme in Case Study #3, a school system in an affluent suburb of a large midwestern city, which has an alternative school for students who are completely unable to function within the framework of the system's conventional schools. At the time of the study, the school had an enrollment of about 45.

There are virtues to this kind of an arrangement—it provides education for children who can't cope with a large urban or suburban high school and all of its associated structure. It is perhaps akin to the alternative of a small college in a world of large universities.

But alternative schools can be misused as dumping grounds for problem students, or as an excuse for the conventional schools in a system to avoid dealing with the need to tailor instruction for independent thinkers as well as hard cases. A better solution would be for conventional schools within a system to become more flexible so as to be able to offer alternative programs and techniques and more individualized instruction. Increased flexibility of this sort also would make more sense in strictly economic terms, because very few school systems in the nation can afford physically separate alternative schools.

Back to Basics. *"Back to Basics" refers to the recent emphasis in education on functional literacy skills. "Back to Basics" may be a reaction to many experimental programs of the late '60s or the recent decline in standardized test scores, such as SAT's. The Curriculum Review Committee felt strongly that "Back to Basics" be correctly interpreted by PTA membership to include the content and methodology in science, mathematics and social studies. The Curriculum Review Committee does not endorse an exclusive emphasis on reading, or "word recognition" and felt that reading is part and parcel of understanding the subject material of science, math and social studies.*

"For a number of years George Gallup has polled the citizenry about American education . . . In the latest poll over eighty percent of people acquainted with the 'back to basics' movement responded in favor of it." [23]

A survey conducted by the authors of the Case Studies revealed a somewhat lower percentage (though still a clear majority) of parents and teachers agreeing that basics are being neglected. But, the report notes, "When that many people agree on a value question, it is wise to look for ambiguity, and there is ambiguity in what the basics are. Most people think of the 'three R's,' reading, writing and arithmetic, when they speak of the basics. In practice, only the bare-bones technical skills of reading and simple arithmetical operations were getting primary attention through this emphasis on the basics."[23]

"As a major need facing education, the basic skills are almost invariably viewed as including reading, mathematics (especially computational skills), communications and language arts skills (both written and oral), and fundamental knowledge in other areas. It is only in this last category that concern for science is indicated, and then only rarely, when the needs are determined by surveys of the population in general."[24]

It is also worth noting that social studies generally is not considered part of the "basics" curriculum.

Though emphasis on acquiring basic skills is at the heart of the educational process, there is a distinct possibility that basics become **the** curriculum rather than just **part** of the curriculum. Another problem, with an overemphasis on basics is a tendency to teach children only those things for which they will be tested, a tendency that leads to mediocrity.

Overemphasis on teaching basic skills at the secondary level must be avoided. These skills should be taught early, because such early emphasis lays the groundwork for total education and higher levels of comprehension and understanding at the secondary level.

At the elementary level, emphasis must be on a total education program to teach children to be able to read and **understand**; to be able to write coherently; and to be able to perform a variety of basic mathematical functions. Such a program would obviate the need for elaborate remedial programs and permit a richer curriculum at the secondary level.

Teaching of basic skills must overlap from one curriculum area to another. In Case Study #1, a junior high school in the system had so compartmentalized instruction that problems in mathematics which affected performance in science courses weren't being worked on. Another difficulty is low reading comprehension which can affect performance in math courses because of students' inability to understand directions. "Cross-over", teaching and reinforcing basic skills using the subject matter of science, mathematics, and social studies can alleviate many of these problems.

Very few of the states currently establish specific competencies in these subjects (science, mathematics and social studies) which students must attain prior to high school graduation, but . . . a number of states are planning to implement basic competency programs in the near future. [25]

As states make plans to implement competency testing and programs, state PTAs must be alert to opportunities for participation in the planning process. Only in this way can such programs be designed with input from parents, as well as the students who will be most affected by such curriculum changes.

Textbooks. *Textbooks refers to those books used as the foundation for course content. This section does not refer to "instructional materials" such as audiovisual, books in school libraries, science equipment or other teaching aids.*

Of the approximately 2,800 textbook titles marketed for use in science, mathematics and social studies, a relatively small proportion of that total were in use in a majority of the nation's classrooms . . . We reached a strong impression that the schools in the case studies were sticking with popular texts and workbooks . . . and were even more impressed by the centrality of these materials in science, mathematics and social studies . . . [26]

Almost without exception, analyses . . . report inadequacies in textbooks used in social studies. The few studies that do report positive findings . . . have compared recent materials to earlier materials and have found improvements. [27]

Textbooks came under criticism in most of the case studies. For example, in Case Study #1, teachers felt the texts were at too high a reading level, especially for the lower grades. Other systems were using texts for the 1960s, and thus science and social studies material tended to be dated.

The NSF's National Survey showed that 20 percent of the nation's mathematics classes, 22 percent of the science classes, and 26 percent of the social studies classes are using pre-1971 textbooks.[28]

Data collected on textbook selection procedures are revealing. "Students, parents and school board members have a rather low involvement in textbook selection; fewer than 5 percent of the schools and districts indicated that any one of these groups is heavily involved. Forty-seven percent of the schools and between 56 and 65 percent of the districts reported that school board members are not involved in textbook selection . . . About one-half the principals . . . are heavily involved in the textbook selection process . . . These results seem to conflict with a recent EPIE study . . . Approximately 45 percent of responding teachers in that survey said they had no role in selecting the instructional materials they were using." [29]

The National PTA has recommended for some time that parents and students become involved in textbook selection and review. The task begins with the process of finding out what is happening with regard to textbooks and instructional materials in your school or district—identifying the textbooks used, finding out about problems with texts, learning who is responsible for textbook selection and the criteria used, and making your views known. The PTA's handbook on textbook selection is a good starting point for concerned parents.

Administrator Issues

Curriculum Supervisors and Coordinators. *"Curriculum Supervisors and Coordinators" refers to professional personnel employed by the school system. Usually, this professional staff is responsible for informing teachers in his/her subject area about available materials, coordinating in-service training, and structuring a cohesive curriculum within and among grade levels.*

"The activities which occupy the largest proportion of state supervisor time are planning and developing curricula . . . providing and coordinating in-service programs . . . working with district personnel . . . and evaluating district programs."[10] At the district level supervisors/coordinators spend most of their time *"planning or developing curricula . . . locating and evaluating instructional materials . . . providing/coordinating in-service programs . . ."*[11]

States in the South were more likely to have full-time state supervisors and coordinators, while the Northeast and West were less likely to have such personnel. "Districts in the Northeast and South are significantly more likely than those in the North Central and Western regions to have one or more district supervisors, while rural . . . and small districts are quite unlikely to have district supervisors." [12]

The researchers working on the case studies noted that state and district supervisors and coordinators appear to be spending less time on curriculum and more on regulatory and program development matters. Also, "As part of the general reduction in funds available to state departments of education, a number of states have reduced the number of statewide subject area coordinators: in many cases a coordinator has been assigned additional duties so that he or she has less time to spend on science, mathematics or social studies education; and in some cases the position has been eliminated entirely." [13]

There is some question as to whether or not the existence of state and district supervisors and coordinators improves the curriculum in a given subject area. The question needs further research. However, parents can ask if such supervisors and coordinators exist in their districts and states, and find out what roles those professionals play. The important point is to find out if teachers have someone they can turn to when they need help—information on textbooks and resources, inservice programs, help with curriculum planning, etc.

Principals. *The school principal has been referred to as the "key factor" in the success or failure of a school. The Curriculum Review Committee felt that this was especially true in the area of curriculum and urge PTA members to cultivate an active and on-going working relationship with their school principals.*

One potential source of instructional help for teachers is their school principal. However, there is evidence that principals may often not be prepared to give this assistance . . . Relatively few principals in any grade range majored in either mathematics or science, while more than 25 percent majored in social studies . . . Considerable numbers of principals at each level indicated they are 'not well qualified' to supervise science instruction, and many secondary principals perceive themselves as inadequately qualified to supervise mathematics and science instruction. [14]

This perceived inadequacy on the part of principals to provide help to teachers in the areas of science and mathematics emphasizes the need for professional help at both district and state levels. Supervisors and coordinators of science and math can provide the support that teachers need.

Principals play a key role in governing the quality of education in a school. Evidence from the case studies and other sources indicates that better schools have better principals, inferior schools have inferior principals. In Case Study #3, the performance of principals in the system is reviewed every year, the administration of the entire system is reviewed every four or five years, and principals often are moved from school to school within the system to avoid "burn-out." Though such a system of rotation would not be practical in many school districts, a system of review certainly has much to recommend it, and parents and students should be involved in the process.

Articulation. *"Articulation" refers to the process of communication within a school, between schools within a district, and between the school and community. The Curriculum Review Committee felt that PTA members can play an especially important role in* *encouraging good and effective communication in these areas: encouraging teachers in one subject area (i.e. math), from kindergarten through high school to exchange ideas on program goals and smooth transitions from grade to grade and from elementary to high school; principals and teachers working together to strengthen one subject area (i.e. K-3 science); and, parents working with educators to ensure that their children's education will be relevant to the working world.*

Articulation of needs is an essential component of a successful school system. Survey results note that "Inadequate articulation of instruction across grade levels is the most serious problem in social studies and mathematics . . . " [35] Also, "articulation of instruction across grade levels appears to be more of a problem in some subject areas than in others. Overall 29 percent of science, mathematics and social studies teachers indicated a need for assistance in this area." [36]

In Case Study #5, a lack of coordination and communication among administration and faculty meant that problems and shortcomings of textbooks weren't being checked. Case Study #2 revealed a lack of articulation from school to school, not only in curriculum matters, but with regard to teaching methods, student problems, etc. One result was that the elementary and junior high schools were perceived as being quite good, but the high school had problems with indifferent students and unhappy teachers. Somehow, something went wrong between junior and senior high.

There must be coordination of learning programs from school to school so the benefits of a good elementary school aren't lost by having a bad high school, or that poor elementary schools aren't sending badly prepared students to high schools which then must devote large amounts of time to remedial work.

Parents should view their school system as a cohesive whole, a continuum through which their children travel for twelve years. They need to find out if there is good articulation within the system, and if lines of communication are kept open—among administration, faculty; and among schools within the system at both administrative and faculty levels.

Consolidation. *"Consolidation" refers to combining students from two school buildings into one building or to merging two school districts.*

Consolidation of school districts is a problem for which there are few set guidelines; it must be dealt with at the district and local levels on a case-by-case basis. The type of consolidation referred to here is that which is brought about by decreasing enrollment. "Enrollments in public elementary schools were increasing from 1955-1969. Since that time enrollments have been declining. Forecasts predict continuing decline until at least 1984 or 1985. Enrollments in public secondary schools were increasing from 1955 until 1976. Enrollments will probably decline in the future until at least 1984 or 1985."[37]

Consolidation often creates curriculum problems. With consolidation come teacher cutbacks and course offering limitations. This was evident in Case Study #4, a consolidated system in rural Illinois: the number of courses offered decreased, which resulted from the need to cut back on faculty. With the decrease in faculty, many teachers must double up and teach courses outside their field. One example cited is an agricultural science teacher who doubles in earth science, so that, in effect, earth science becomes agricultural science. Another example is a junior high science teacher who also coaches both the boys' basketball and football teams. This cuts greatly into his preparation time for science courses.

In addition to curriculum problems, consolidation also can mean the loss of various positive elements in the school system—problems of isolation of faculty from local communities, decreased parental or family influence on children, breakdowns in communications between school and family, and loss of PTA strength.

Parents must be aware of the effects consolidation may have on the curriculum and on the school system and must make sure they are a part of the decision-making process should they be faced with this issue. As participants in this process, parents can ensure that their priorities are heard and are incorporated into any decisions made concerning consolidation.

Emergency Situations. *"Emergency Situations" refers to unanticipated occurrences that prevent the use of the school building. The Curriculum Review Committee encourages PTAs to actively assist in developing plans before such crises happen.*

During the severely cold winter of 1976-77, the school system of Columbus, Ohio, faced a crisis. Most of the schools were forced to close for several weeks because they could not obtain fuel to heat buildings. The system coped as best it could using a few buildings, a great deal of home study, and the local TV facilities. As presented in Case Study #8, the Columbus experience showed that emergencies of this sort require total community involvement if schools are to continue to function in any meaningful way.

School systems should develop contingency plans for dealing with emergency situations which have the potential to last for several weeks. PTA units can be active in making and implementing such plans. Of great importance is the need to find ways to adapt the curriculum to emergency situations. Curriculum flexibility is important in order to keep the learning process moving as smoothly as possible. The use of educational radio and TV should be given a major role in any such planning.

Section III—Summary and Conclusions

This report has touched only briefly on the abundance of material provided in the NSF status studies. The Curriculum Review Committee has provided this report in the hope that (1) PTA members will find within this report issues of interest for pursuing at the local level and (2) many PTA members will order one or more volumes of the NSF status studies (Appendix A in this report) and apply this definitive research to problems in local schools on issues that may not have been included in this report.

Finally, three sets of specific questions about mathematics, science and social studies (Appendix B) have been formulated for your use. The purpose of these questions is to generate one-to-one dialog between parents and teachers about what their children are being taught, how they are taught, and what they are learning. It is from this type of dialog that the Committee feels that parents can begin to have meaningful involvement with curriculum issues. The Committee hopes that parents will use these questions to be supportive of teachers and administrators and that parents will work cooperatively with them to ensure quality education for their children.

Parents often shy away from involvement in curriculum development under the mistaken assumption that curriculum is an area best "left to the experts." However, sound curriculum planning requires input from parents who have a good idea of what their children should be learning; from students who are doing the learning, and from the community outside the school, the community in which the students must live and function.

Parents must be encouraged to pay attention to what is happening in their schools. This effort on the parents' part must be matched by the schools' effort to reach out, to keep parents informed, and to avoid putting barriers in the way of parental involvement and understanding. The road to good curriculum and good schools is teamwork, in which parents, teachers, administrators and students work together.

Focusing parental influence on the right places in the school system is a key technique for obtaining information about curriculum and then solving problems. This may mean expressing concerns and exerting influence on school boards, principals, curriculum supervisors and coordinators, teachers, or any combination of these professionals within the system. Parents must learn how school systems work in order to be effective. Who decides what the curriculum in your school will be? Is there a curriculum development or curriculum review committee? Who is on it—education professionals, business-people, parents, students? How much curriculum input comes from the federal government, the state, and the district? How much money is spent for curriculum development, for textbooks, for nontext materials, for inservice training? These are but a few of the more generalized questions that concerned parents may wish to ask.

The National PTA will continue to provide as much help as possible to its members in their efforts to obtain the best possible curriculum for their schools, through various PTA publications and the organization's magazine *PTA Today*. In addition, this report and the NSF survey materials upon which it is based will be the core of a workshop in curriculum to be held at the PTA's 1979 National Convention.

To summarize:

> Scrutiny of curriculum development is a legitimate and necessary activity to be undertaken by PTA units and councils.
>
> While curriculum offerings depend heavily on a given school's teachers and principal, and upon the professionals at district and state levels, in the final analysis curriculum is built on the expectations and understanding of the total community.
>
> When inquiring into curriculum, a nonjudgemental approach is important. Curriculum inquiry must be positive, supportive and rational.
>
> Curriculum development and review committees should include parents, students and members of the community at large, as well as professionals from the educational field.
>
> Finally, the PTA proposes conferences on curriculum development to be held with organizations that share similar concerns (including the other groups which are evaluating the NSF survey materials). Such conferences should include parents, students, teachers, research professionals, supervisors and coordinators, administrators, and teacher educators.

Appendix A

The NSF Status Studies in Science Education Volume Titles, Accession Numbers and Order Information

The PTA encourages its members to review the NSF status studies of science education for themselves. These volumes provide a wealth of useful information about the current status of science, mathematics, and social studies education in the United States today.

When ordering, be sure to include full title of volume, SE number, and stock number. Especially recommended is the summary volume (the last one listed below). It contains an excellent distillation of the conclusions reached by the NSF-sponsored researchers, as well as a succinct and useful overview of the project as a whole.

The Status of Pre-College Science, Mathematics, and Social Studies Education: 1955-75. Volume I, *Science Education,* SE 78-73 I, Stock No. 038-000-00362-3, $4.25. Volume II, *Mathematics Education,* SE 78-73 II, Stock No. 038-000-00371-2, $4.50. Volume III, *Social Science Education,* SE 78-73 III, Stock No. 038-000-00363-1, $6.25.

These volumes are a literature review examining documents relating to the three subject areas and are useful for putting science, math, and social studies teaching in historical perspective.

Case Studies in Science Education. Volume I, *The Case Reports,* SE 78-74 I, Stock No. 038-000-00377-1, $7.25. Volume II, *Design, Overview and General Findings,* SE 78-74 II, Stock No. 038-000-00376-3, $6.50.

Eleven in-depth investigations of eductional practices, centered on but not restricted to science. Volume I is full of fascinating details of real-life schools, and Volume II has a wealth of interesting interpretive material.

Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education, SE 78-72, Stock No. 038-000-00364-0, $6.50.

A national survey of teachers, principals, and superintendents regarding training, materials, and educational practices. Primarily statistical, but much important basic data.

The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U. S. Schools: An Overview and Summaries of Three Studies, SE 78-71, Stock No. 038-000-00383-6, $3.50.

An excellent summary document of the entire project, presenting an overview of the above three components. Highly recommended.

Appendix B

Questions Parents Can Ask About Science

Following are some possible questions for parents and others to use when investigating the science curriculum in their schools:

Does your school's science program have a clearly stated scope and sequence of content and processes to be taught at each grade level?

Does the program provide for individual differences among students, and different levels of learning?

Is your school's science program "up-to-date?" For example, is the scientific content current? Are textbooks reasonably new, or are they older texts containing outdated information and concepts?

Are NSF-developed curriculum materials available, and are they being used? Are any other university-developed curriculum materials available and in use? Are these materials written and assembled in a clear, straightforward manner? Do these curriculum materials allow students to practice inquiry and problem-solving?

Is there laboratory work of various kinds in the science curriculum? Do curriculum materials permit and encourage laboratory skills and their development, manipulation, and hands-on learning? How much time is spent in laboratory work as opposed to lecture or textbook learning? Is the surrounding environment used as part of the science curriculum? Are there field trips—for example, to museums, planetariums, aquariums, forests, parks, environmental centers, water treatment plants, and other facilities outside the classroom?

Are there adequate inservice programs at the local and/or district level? At the state or national level? Are there opportunities for teachers to update their scientific publications, etc.? Are there inservice programs and publications from which teachers can learn new techniques for teaching science? Are there inservice programs designed to meet the needs of newly assigned teachers, especially those who have just been assigned to a new grade?

Are there opportunities for teachers at different grade levels to communicate with each other in areas of mutual interest and to share information that can help build a strong science program?

Does our school have adequate teaching materials and supplies? Is laboratory equipment sufficient, up-to-date, and usable? Is there access to multi-media and audio-visual materials? Are hands-on materials available and used? (For example, does your school have manipulative materials for teaching concepts such as smooth and rough, heavy and light, etc., to primary students?) Are low-cost hands-on materials being used in your schools? Do teachers find ways to make and use low-cost hands-on materials using everyday, inexpensive items? Are they being provided with information on how to make and use such materials?

Are counselors being given adequate science information so as to assure proper placement of students in science courses according to students' desires, needs and interests?

Are there resource people within the school system and the community at large who can evaluate ongoing and newly adopted science programs? Are there community resource people who can be called upon to provide curriculum enrichment—for example, a professional meteorologist, a naturalist, or an engineer who can be brought to the school to meet with students?

Questions Parents Can Ask About Mathematics

What is the mathematics curriculum for your school/district? Is this curriculum defined through objectives or student learning goals? Do these objectives allow for individual differences of student abilities?

Does the content defined in these objectives contain a balance of concept development, computational skills and problem-solving skills?

Are criterion referenced tests administered to measure student's achievement of objectives?

How often are these objectives and tests reviewed and/or revised?

Does the mathematics curriculum stress not only computational skills but skills determined essential by the National Council of Supervisors of Mathematics such as problem solving; applying mathematics to everyday situations; alertness to the reasonableness of results; estimation and approximation; geometry; measurement; reading, interpreting and constructing tables, charts and graphs; using mathematics to predict; and computer literacy?

Are manipulatives utilized as an integral part of the instructional program? Are these manipulatives available in sufficient quantity to allow for **both** teacher use and student use?

Are textbooks up to date? Are mathematics textbooks periodically reviewed? What process is used to determine which textbook(s) will be used? Is there sufficient supplementary material (non-book, audiovisual, etc.) to allow for different student learning modes?

How much time is devoted to mathematics instruction? Of the time, is a minimum of half the time spent in teacher-student developmental activities? Are drill and practice activities preceded by meaningful instruction?

What is the philosophy of testing in your school/district? Are both standardized tests (nationally normed tests) and criterion referenced tests (locally normed tests) administered? Are the results of these tests utilized for student and program evaluation? Are the results of these tests utilized to plan for program change and/or improvement? What provisions are made for sharing this information with parents?

What provisions are made for the academically talented student in mathematics? Is such a program state mandated?

What provisions are made for the special education student in mathematics? Is such a program state mandated?

Does your district/school have a Title I program? If so what percentage of time and funds is devoted to mathematics?

What provisions are made for teacher inservice training in mathematics?

High School

Does your school/district have or are planning to have a computer awareness/computer literacy program?

Are there mathematics courses available for the non-college bound student?

Does the mathematics program incorporate career awareness opportunities?

Questions Parents Can Ask About Social Studies

Following are some questions which parents and other concerned citizens can ask about the social studies programs in their schools:

What is the social studies curriculum in your local schools? Are there stated goals or objectives? Are they realistic for various age levels?

Allowing for the varying degrees of sophistication at different levels, is social studies limited to history and geography, or does it also touch on economics, political science, sociology, anthropology, and consumer education?

Is there scope and sequence in the program? In other words, is there continuity in the general plan so that one year's effort leads to the next year's plan?

Is the program taught differently at different levels? An elementary child may learn economics from a play store, but older children require a different method of teaching as well as more challenging subject matter.

How does social studies reflect other goals in your school? For example, is it used to reinforce the teaching of reading?

Are there certain concepts your school is trying to teach that can be used as a focus for the social studies program? For example, if cooperation is a focus, elementary children can understand the concept as it applies to the classroom or neighborhood, and the same concept can apply to relations between nations as taught to high school students.

Does your program stop at teaching only by the recall method (I'll tell you and you see if you can remember it to tell back to me), or does it allow for divergent and higher levels of thought?

Does your program teach children to apply the concepts and facts they learn?

Does the program teach map skills, chart and graph skills, research skills, and data skills (the ability to interpret, analyze and challenge)? Does it teach children how to solve problems? How to develop independent thinking after reading data? How to draw inferences so they understand the effects of facts on history, geography, economics, etc.?

Does your school's social studies program take advantage of local resources—both places and people—in history, geography, politics, etc., so that children can learn to appreciate their communities?

Since social studies must necessarily deal with controversial subjects, what safeguards does your school system provide so these subjects are fairly presented to students?

Is there a policy to permit review of textbooks on a regular basis so they remain current? Does your system allow adequate funds for local schools to replace outdated texts?

Are there procedures for allowing parents to participate in the review and choosing of new textbooks? Are there state book lists from which texts must be chosen? Are such lists adequate to allow for diversity of needs in local school systems? Who sits on state committees that produce these lists? Are they representative of the entire state?

Is there an appeal procedure by which a parent may challenge, in a proper administrative manner, the choice or use of a text? Who is a final arbiter of such a challenge? (In most systems, the school board has the final legal responsibility.)

Most important is the need to look at more than one grade so you get an overall picture of the social studies curriculum, rather than a narrow perspective that might be distorted. Be sure there is a balance in the total school curriculum—while a system must concentrate on developing reading and mathematics skills, adequate time should be allowed for an effective social studies program.

References

1. 1977 National Survey, p. 137, See also Table 64, p. 139.
2. Status: Mathematics, p. 178. See also Table 8, p. 129.
3. Status: Science, p. 62
4. Status: Science, p. 53
5. Status: Mathematics, p. 179
6. Status: Science, p. 60
7. Status: Mathematics, p. 178
8. Status: Mathematics, p. 178
9. Status: Science, p. 191
10. Status: Mathematics, p. 178
11. Case Studies, Vol. II, p. 12:4
12. 1977 National Survey, pp. 101, 105
13. 1977 National Survey, pp. 107, 109
14. 1977 National Survey, p. 148
15. Status: Science, p. 33
16. Case Studies: Vol. II, p. 13:66
17. 1977 National Survey, p. 159
18. 1977 National Survey, p. 134
19. 1977 National Survey, p. 128
20. Case Studies, Vol. II. pp. 14:14-15
21. Status: Science, p. 164
22. Status: Mathematics, p. 77
23. Case Studies, Vol. II, p. 13:34
24. Status: Science, p. 150
25. 1977 National Survey, p. 31
26. Case Studies, Vol. II, pp. 13:61-52
27. Status: Social Science, p. 118
28. 1977 National Survey, p. 95
29. 1977 National Survey, pp. 98-99
30. 1977 National Survey, p. 30
31. 1977 National Survey, p. 40
32. 1977 National Survey, p. 36
33. 1977 National Survey, p. 33
34. 1977 National Survey, pp. 43-48
35. 1977 National Survey, p. 162
36. 1977 National Survey, p. 149
37. Status: Science, p. 7

The Curriculum Review Committee—Edna Polin, Chairperson

Suzanne Arriola (California)
Eileen Dietz (Nebraska)
Sara Frazer (Tennessee)
Darlene Hutchison (Utah)
Ann Kahn (Virginia)
Karen Leveridge (Oklahoma)
Bettye Lis (Tennessee)
Lois Overbeck (Ohio)
Rose Pfund (Hawaii)
Charlotte Ryan (Massachusetts)
Winnie Slusser (Illinois)

Consultants to the committee—

Jerry Hayes, Coordinator, Bureau of Science, Chicago Board of Education

Jim McCarthy, Coordinator, Bureau of Social Studies, Chicago Board of Education

Marie Jernigan, Coordinator, Bureau of Mathematics, Chicago Board of Education

Additional mathematics questions prepared by—

Mary Kay Karl, Math Consultant, Schaumberg Township Elementary Schools

This report was prepared by James C. Clark.

Copies of this report are available from the National PTA. Appendix B of this report is available as a separate brochure from the National PTA.

blank page

Math, Science and Social Studies Curriculum: Retrospect and Prospects

The NSBA Panel on Curriculum Trends and Developments*

Foreword

Change is inevitable, the axiom goes. Yet to a great extent, the more things appear to have changed in America's public schools, the more they have remained the same.

This is the overriding theme of a series of studies commissioned by the National Science Foundation (NSF); studies upon which this Research Report is largely based. The NSF studies consist of three extensive literature reviews (one each of math, science and social science curriculum from 1955 to 1975), a 1977 national attitudinal survey of teachers, principals, superintendents and district curriculum supervisors, and two volumes of case studies in science education.

Overall, the NSF-sponsored studies conclude that for all the talk and all the dollars, neither the content nor the method of teaching math, science or social studies has changed all that much in the past twenty years. Those curricular changes and innovations which have been unveiled since 1955 often originated outside the schools—within the walls of textbook publishers, academe and state and federal government agencies. As such, few significant changes in school curricula or instruction have sifted down to the classroom. Even fewer of these new approaches survive today in their original form, having fallen victim to a variety of ills: the absence of defined, agreed-upon objectives for the district's instructional program; the absence of coordinated curriculum planning at both the district and building levels; and teachers who are often ill-prepared or unwilling to implement what they view as the latest curricular fad. This Research Report, then, has one fundamental purpose: to enhance the ability to board members and administrators to set a well-thought and consistent course for their schools' instructional programs.

Thomas A. Shannon
Executive Director
National School Boards Association

Introduction

BACKGROUND ON THE NSF-SPONSORED STUDIES

The literature reviews were conducted in 1976 for NSF by the Center for Science and Mathematics Education at the Ohio State University and the Social Science Education Consortium, Inc. The reviews analyzed and examined practices in schools and teacher education between 1955 and 1975. The literature searches were conducted from data bases such as ERIC, reports to federal education agencies, *Dissertation Abstracts International, Education Index,* state department of education reports, professional journals and scholarly works and data from various government agencies and accrediting agencies. Both descriptive and evaluative literature were studied. The result of the project is three separate reports which synthesize the findings for science, math and social science education.

The 1977 National Survey of Science, Mathematics and Social Studies Education was conducted by the Research Triangle Institute under NSF contract. Superintendents, curriculum supervisors, principals and teachers completed questionnaires which yielded information on course offerings, curriculum usage, enrollments and classroom practices. The sample was designed so that national estimates could be made from the sample data.

The case studies were conducted and organized by a team of educational researchers at the University of Illinois. The studies were undertaken to provide

---

*Information reported in NSBA Research Reports does not necessarily reflect official viewpoints of the Association.

This report was published as Research Report 1979-3 by the National School Boards Association, Washington, D.C.

NSF with a portrayal of conditions in K-12 science classrooms.

THE NSBA CURRICULUM SYMPOSIUM

In April 1979, NSBA convened fourteen selected school officials—school board members, superintendents and curriculum specialists—to share their reactions to the findings of the NSF-contracted research and to discuss curriculum trends and policy-making in the future. The experiences and opinions expressed at the symposium, held at the NSBA Convention in Miami Beach, form the basis for the last two sections of this report.

Retrospect: The NSF-Sponsored Studies

Curriculum Control, Supervision and Funding

Control of the public school curriculum does not lie with school board members, administrators or even teachers. Nor does it reside with textbook publishers, who, to a large extent, determine course content. Rather, curriculum matters are controlled ultimately by those outside the education field who hold the purse strings and set regulations and mandates for the schools. A particular textbook will have no effect on what students learn if a school district lacks the funds necessary to buy the books. Moreover, the importance of a particular subject may be undermined if state regulations require students to study it for only one year as a requisite to a diploma. Similarly, the quality of teaching and teachers' familiarity with curricular innovations often reflect state certification requirements. And far-reaching goals of the federal government—such as improving the United States' technological position or making education more equitable for certain groups of students—greatly influence the appropriation of federal education funds.

FEDERAL SUPPORT

The role of the federal government in curriculum development perhaps is best illustrated by the surge of popularity which the sciences enjoyed in classrooms across the U.S. in the late 1950s. The National Science Foundation (NSF), which was established by the federal government in 1950 to promote basic research and education in the sciences, did not really get off the ground until the Soviet launching of Sputnik in 1957. How could the United States hope to compete successfully in the space race if its students were not adequately trained and prepared, the reasoning went. In 1957, then, NSF undertook the process of curriculum reform on a major scale. At that time, extensive NSF support was given to develop a number of alternative programs. Among these: Elementary Science Study (ESS), Science—A Process Approach (SAPA) and Science Curriculum Improvement Study (SCIS). NSF also developed several innovative textbook programs, such as Biological Science Curriculum Study (BSCS) and Introductory Physical Science (IPS).

Federal influence on curriculum in the late fifties and sixties extended beyond the National Science Foundation. In addition to NSF, the National Defense Education Act (NDEA) of 1958 and the Elementary and Secondary Education Act (ESEA), passed by Congress in 1965, provided considerable financial support for curriculum development, equipment purchases and teacher education. The limited extent to which alternative projects were actually implemented and their impact on the classroom will be discussed later in this report.

The trend of increasing federal financial support for the sciences and for education generally peaked in the late sixties. Federal revenues accounted for 8.8 percent of the school funds nationwide in 1967-68; the federal share dropped to, or below, 7.5 percent each year from 1968 to 1975—with the exception of 1971 to 1972. Moreover, the researchers conducting the science study for NSF conclude, "based on past patterns of state and federal funding it is not likely that many states will give science a high priority since federal legislation does not."

THE STATE ROLE

The statistics bear out this conclusion. The percentage of state support for science education has remained virtually unchanged since 1955. In addition, neither science nor mathematics are generally included in state education needs assessments. In those states where needs assessments have questioned citizens about priorities for what students learn, "knowledge of basic skills" and application of skills to real-life problems" have emerged high on the list of needs. In most states, relatively little attention has been given to the history, status or needs of mathematics education. Similarly, when science is included in state needs assessments, the stated needs increasingly reflect concern for practical life and work skills.

However, while state support for science education has remained level, the influence of states on science education has increased markedly since 1955. As the NSF-sponsored report on science curriculum states, "In recent years the number of legislation and regulation items has increased. While funds have been provided by states for some of these requirements, in other cases funds have not been provided. Passage of legislation or regulation items without funds is frequently [an] action influencing the curriculum."

State requirements that affect local district curriculum decisions include, among others, graduation requirements for particular subjects and specific course requirements within subject areas—health and hygiene, for example, within the area of science. Whether or not state requirements are advantageous to a particular subject area depends, of course, on the importance placed on that subject by the state. For instance, most states require only one year of math and science in grades 9-12 but more than one year of social studies. On the other hand, math is more often cited in the competency requirements now mandated by more than three dozen legislatures.

The growing influence of states in public school curriculum matters has had both positive and negative effects. On the positive side, state policies encouraging school district consolidation in the state were common in the fifties, sixties and early 1970s. Such policies helped foster larger schools which in turn were able to offer a wider variety of courses and educational opportunities.

In the negative column, as state priorities have changed and moved away from curriculum concerns, so have state funds. State activity in larger societal issues—such as equal educational opportunity—accelerated rapidly in the middle 1960s and continues today. These equal opportunity requirements—including provisions for the handicapped, minorities, females and children from low income families—have, in some cases, channeled funds away from certain curricular areas, such as instructional materials, field trips and inservice education.

Because relatively few states have minimum support levels for educational materials like those that exist for teachers' salaries, expenditures for instructional materials tend to increase rapidly when general education funds are plentiful and decrease just as quickly when the purse strings are tightened. Unfortunately, since the early 1970s, many schools have experienced the latter; science textbooks, for instance, are not being replaced as rapidly in the mid-seventies as they were in the late 1960s.

Although state governments wield a growing say in how and where state education dollars are spent, state regulations concerning the curriculum are relatively few in number when viewed against the federal government's role. Increasingly, federal aid to the public schools has been categorical, and often the precise nature, scope and direction of curriculum reform is predetermined. ESEA funds, for example, are channeled into "supplementary" programs (programs above and beyond what the school is providing) for certain groups of students. Local education agencies often feel compelled to adhere to specific curricular guidelines.

SPECIAL INTERESTS

Although local curriculum decision-makers have lost some power to federal and state agencies, big government does not pose the only threat to local board of education control of the school curriculum. In recent years, various groups have attempted to exercise influence over the curriculum. These efforts have included:

> Scholars' attempts to give students particular content from their subject areas, even though it may be contrary to the ideas and research of professional educators and curriculum leaders;
>
> Increased militancy by teacher organizations has removed many curricular decisions from the domain of the school boards as matters such as organization and textbook selection become negotiated items in teacher contracts; and
>
> Special interest community groups have increased in strength and number, especially in big cities, at the expense of the centralized control of schools.

Promoting change and determining the direction of curriculum is not, then, simply a question of dollars; the often-divergent interests of a variety of individuals and groups must be taken into account. As the NSF-supported report on mathematics points out "to argue simply for more money as the solution to educational problems ignores present realities. At issue is investing money wisely in order to accomplish change expeditiously and efficiently . . . The recognition of the deficiencies in the policy formation process is an important first step toward improving the payoff of the investment and toward improving the learning and teaching in the schools."

PITFALLS IN POLICY-MAKING

That same report identifies three "primary" pitfalls that ensnare the policy-making process:

> Educational policy frequently is determined without first collecting enough information to

> allow the process to be rational. Policy-makers must learn more about what actually happens in the typical classroom. They often know too little about teaching methods, instructional tools, or the overall curricula.
>
> Educational policy frequently is constructed without using information that is readily available. Too often school districts fail to take advantage of readily available curricular information and resources. This can be the result either of a lack of information or of failure to act upon what information is available.
>
> The point at wnich values enter into policy formation, and the effects of different values, frequently are not dealt with as educational priorities and curriculum decisions are being set. Policy-making generally incorporates two considerations: judgments based on information and judgments based on political grounds or reactions to prevailing societal attitudes. Research shows that a change in values results only when there is significant agreement across these two levels.

Adequate information and prior consideration of values, then, emerge in the NSF-sponsored studies as key—and often lacking—requisites to meaningful curriculum policy-making. Money alone does not bring about useful change in the curriculum. Funds—be they federal, state or local—should be looked upon as an investment; and, as with any investment, information must be collected to ensure a successful outcome. In this case, information regarding practices in the schools must be gathered from all available sources and the information must then be effectively applied. Only then can the needs of various groups be balanced, and only then will the payoff—productive change in the curriculum—result.

Curriculum Objectives

There's been a lot of talk during the last two decades about new curriculum objectives: we've heard about "new math," citizenship education, and environmental studies which will prepare students for the modern technological age. Yet for all the talk and media coverage of these innovations, the broad curriculum objectives in mathematics, science and social studies have changed very little in twenty years.

The NSF-sponsored report on math education between 1955 and 1975 suggests that while the number and variety of courses offered at the secondary level increased during the period, "new math" has had little, if any, lasting effect on the overall math curricula. The new math—characterized by an emphasis on process and systems instead of mechanics and manipulation—simply was not adopted in many schools. Moreover, many of those instructional changes that were made in teaching math between 1955 and 1965 have disappeared from the classrooms in the seventies. Topics popular in 1960, such as sets and non-decimal numeration systems, are practically nonexistent in present elementary school math materials.

Likewise, objectives in science curriculum, particularly at the elementary level, did not change markedly in two decades, the studies completed for NSF found. Emphasis on the processes of scientific inquiry was the predominant instructional mode in 1955; so it was in 1975. Similarly, the scope and sequence of the social studies curriculum have remained stable, although there have been a few persevering shifts within that framework. These "shifts" have included a greater emphasis on teaching concepts and relationships instead of isolated facts.

CURRICULUM 'IDENTITY CRISIS'

There are numerous reasons why few curricular innovations and new curriculum objectives have taken hold in the schools. Certain explanations, such as lack of teacher training and limited use of innovative teaching materials, will be discussed later in this report. Frequently, however, curricular changes have languished and died because they were introduced without defined objectives or stated connections to the district's overall instructional program. Say NSF-supported researchers: "The social studies have undergone a continuous identity crisis during the past twenty years; [as such] it is difficult to speak of 'goals' in the field, for it is difficult to set goals until one has some notion of the needs."

One of the main obstacles to determining objectives for social studies has been defining the boundaries of the field. A variety of needs and purposes, some of which are contradictory, have been advanced by educators; debate continues even today about the role of social science in social studies.

Neither has the field of mathematics been immune to the lack of consistency in goals and objectives. Disagreement over the identification and prioritization of goals—among educators, the public, college personnel, classroom teachers and students—is common. Although the dissonance in goal-setting has been prevalent for the past two decades, in the 1970s there have been particular discrepancies between the public's concern for "the basics" and educators' concern for students' comprehension of less tangible mathematical processes.

IMPACT OF THE 'BASICS' MOVEMENT

Indeed, the "back-to-basics" push which hit full stride in the mid-70s has directly influenced general curriculum objectives. Growing emphasis has been placed recently on the structure of science—the facts, concepts and principles—rather than on the processes of science, which predominated during the late 50s and 60s and continued into the early 70s. This may be due, in part, to mounting concern over declining student achievement test scores. The new emphasis on facts reflects increasing demands that schools be accountable. It is easy to see that a student's recollection of scientific "facts" can be more easily measured than can his grasp of science "processes."

The social studies have felt the impact of the emphasis on the "basics." Money spent on materials and equipment and time allotted to social studies are down as schools reallocate resources to the three Rs. Even within the group of social studies educators themselves, disagreements exist over the best approach to teaching the subject. Some of the social studies educators attending a recent conference argued for a move toward less history and more global education (or fewer facts and more skills); others at that meeting endorsed an emphasis on the basics through traditional social studies. This meeting, in addition to being indicative of the influence of the basics, points up graphically the difficulty of arriving at common curricular objectives.

It has been suggested that the problem of conflicting objectives and goals exists not only within specific disciplines but within the public schools as a whole, as well. Schools are expected to play dual, and often contradictory roles: to facilitate progress and reform in society while, at the same time, maintaining and promoting existing cultural and societal values. This "split personality" has contributed to the development of ad hoc curriculum policy which is characterized by "disjointed incrementalism"—the introduction of bits and pieces instead of the acceptance of the overall foundation and objectives. Curriculum policy has been marked by an absence of comprehensive, defined goals and objectives, and lack of matching strategies to reach those objectives.

In spite of the splintering of objectives, several general instructional approaches are common to math, science and social studies curricula of recent years. These approaches—combining innovations from the past two decades with the recent emphasis on the basics—include:

> **More individualized, prescriptive teaching.** Increasingly, teachers are responding to the fact that students are ready for specific tasks at varying levels; teachers are providing for individual differences.
>
> **Increased use of behavioral objectives.** Teachers are specifying what students are expected to accomplish—a group of students completing a series of lab projects, for example—when it will be achieved, and standards against which the work will be measured.
>
> **Increased emphasis on the basic skills within other subject areas.** More and more teachers are being called upon increasingly to teach reading within their subject areas, for example.

The Classroom

As discussed in the preceding section of this report, the NSF-sponsored studies suggest that objectives in math, science and social studies have not changed much over the past two decades. And where stated objectives have changed, these objectives have had little lasting impact on classroom procedures and outcomes. Moreover, **what** students are learning has not changed greatly, so too has **how** they are being taught changed little since 1955.

Educators have long searched for a better pattern of school and classroom organization. Accordingly, some new practices have been introduced in the past quarter-century. In 1955, the use of specialists—especially in math—was seen as the answer to poor preparation of elementary school teachers. During the early 1960s, various nongraded and multi-graded instructional approaches were unveiled and team-teaching was proposed as an alternative to departmentalizing. The "open classroom" was often espoused in the late sixties as a way to make schools less rigid.

Although portions of these innovations linger today, the general pattern of school and classroom organization continues little-changed; the graded, self-contained elementary classroom and the fixed-period schedule at the secondary level still predominate.

Surprisingly perhaps, the NSF-supported studies suggest that in spite of all the discussion about organization, instructional approaches may not be all that important. The math researchers conclude that no one organizational pattern appears to increase student achievement in math. Good teachers can be effective regardless of the school's instructional organization.

THE ROLE OF THE TEXTBOOK

Within the classroom, teaching procedures have changed little in twenty years. The importance of the textbook in determining both instructional patterns and curriculum content cannot be overemphasized. According to the NSF-sponsored studies, the textbook continues to play the primary instructional role in science, mathematics and social studies classes. Teachers tend to adhere firmly to the idea of "covering the material" in the text; moreover, covering it in the sequence as presented in the text.

Textbooks not only determine the curriculum in individual classrooms and schools, but also tend to create a homogenous national curriculum. The NSF-supported studies found, for example, that while math textbooks at the elementary level do vary, the basic components of the curriculum have become standardized; the differences that exist tend to be largely in approach, design and the amount of space allocated to specific topics.

Mathematics classes clearly are the most influenced by a single textbook. The NSF-contracted national survey found that about half of all science and social studies classes—on both the elementary and secondary level—used a single published textbook or program in 1977, whereas almost two-thirds of math classes used a single text or program.

Although textbooks do play a major role in determining curriculum and content, the textbook's role is not as dominant as it once was. Prior to 1960, curriculum was based primarily on a textbook in elementary classrooms and on a textbook series in the secondary schools. With the use of federal funds in the 1960s, alternatives to traditional text materials—such as self-contained learning kits and audio visual aids—were developed. Increasingly, these new instructional materials seem to have taken hold in American school classrooms.

Textbooks and other instructional materials obviously play a significant role in what children learn. It follows, then, that the process by which these instructional materials are selected is considerably important. Principals, superintendents and district curriculum coordinators responding to the NSF-sponsored study reported a patchwork process by which textbooks were selected. Each of the three groups agreed that school board members, students and parents were not significantly involved in the selection of instructional materials. Well over half of the districts reported that school board members were not involved in textbook selection. At the same time, only half of the curriculum supervisors and principals said they were heavily involved. Surprisingly, only twenty percent of the districts reported that the superintendent was heavily involved in choosing textbooks.

Who, then, is selecting textbooks and other learning materials? Responses from each group suggest that teacher groups and individual teachers may now wield the most say in the textbook selection process. This finding, however, conflicts with a recent Educational Products Information Exchange (EPIE) study in which teachers were asked about their involvement in textbook selection. Almost 45 percent of the teachers surveyed claimed they had **no** role in selecting instructional materials. Apparently, no group feels it has control over the textbook selection process.

As discussed earlier, mathematics classes tend to rely more heavily on textbooks than do science and social studies classes. Science and social studies classes are more likely to include alternative activities such as field trips, student projects, guest speakers, slides, tapes and records. The use of "manipulatives" ("hands-on" materials such as scales and meter sticks) is more common in science courses than in social studies or math classes.

LIMITED USE OF EQUIPMENT

Not surprisingly, the classroom teacher remains the primary conduit of instruction for most students, the NSF-supported studies found; although there has been a general increase in student-centered learning activities (such as lab work), the lecture is still the predominant method of instruction in most classrooms. Interestingly, this traditional approach is not necessarily due to lack of equipment. The NSF-sponsored national survey found, for example, that while more than three-fourths of U.S. elementary schools have microscopes, only 28 percent of the grade K-3 science classes and 59 percent of the 4-6 grade classes ever make use of them. Similarly, the availability of computer terminals in schools is more widespread than the extent of their use would lead one to believe.

Generally, then, classrooms have changed little over the past two decades. The predominant patterns in classrooms continue to be: instruction with total class groups; tell-and-show, followed by individual student work (in elementary schools); and lecture-homework at the secondary level. In the social studies, for example, the NSF-supported studies suggest that while new social studies projects—such as role playing and the use of inquiry-based instruction—have had **some** influence on teaching styles, they have had little influence on textbook selection, the employment of teachers or teacher training. Moreover, the data show these "new" social studies projects have been adopted in relatively few classrooms.

As noted previously, the NSF-contracted research suggests that the pattern of classroom organization may not be that important. An individual teacher can be effective regardless of curriculum, the availability of learning resources, or the organization of the school or classroom. So, too, may curricular innovations not play all that significant of a role in the end product of instruction—a child's education. Educational research supports the general notion that there is no one best method of instruction for all students. Thus it follows that individual teachers may teach best in various ways, and that specific course content may be best taught differently. With that idea in mind, this report now turns its attention to the teacher.

Teachers and Teacher Preparation

Differences among various curriculum programs generally have been attributed to differences in curricular materials. The NSF-supported studies suggest a contrasting view: that differences between programs—as well as the benefit children derive from different programs—may be due largely to the skill and enthusiasm of the teacher.

In "Elementary School Science: A 1975 Reflection" (*The High School Journal*, Feb., 1976), professor of science education David Butts writes: "The effectiveness of the science reform programs has been directly dependent upon the preparation of the teacher." In the article, he goes on to note that education decision-makers must determine when, where and how teachers will receive this training. Further, Butts emphasizes administrative support as an important factor in the effectiveness of training programs; teachers must be given the opportunity for experience, practice and training once they are on the job.

INADEQUATE PRESERVICE TRAINING

Overall, the NSF-sponsored studies conclude that preservice teacher education is inadequate in science, math and social studies. The science report, for instance, points out that the bulk of students' science instruction takes place in grades 7-10. Ironically, though, data show that junior high science teachers have the last adequate preparation in course content, the fewest certification programs available, and access to the poorest instructional facilities. And even though secondary school science teachers currently are younger and better educated than they were in the fifties, there remains a critical need for inservice education, as indicated by research and confirmed in attitudinal studies of teachers themselves. Elementary science teachers are in the same predicament. Certification standards, specifying, among other things, required course hours, have not changed much over the past two decades.

Similar deficiencies surface in the education and training of social studies and math teachers. While there has been a gradual shift away from an emphasis on history to more social science courses in teacher training programs, this shift has had little effect on state certification requirements. Social science certification requirements have remained relatively static since 1955. As such, social studies teachers may not be all that well prepared to teach the "new" social studies, which are characterized by an emphasis on the social sciences.

So, too, many math teachers have been ill-prepared for the pendular fluctuations in instructional approaches. Little in the way of a widespread, coordinated effort was undertaken in the sixties to prepare elementary school math teachers for the content and thrust of the "new math." Teachers, therefore, tended to emphasize in classrooms the things they knew best and felt they could best teach—computational skills with whole numbers, fractions and decimals. When and where efforts were made to provide inservice for elementary math teachers, the emphasis usually was placed on content—particularly terminology—rather than on the methodology which was an integral part of the "new math" concept.

TEACHERS' SELF-PERCEPTIONS

Given teacher training programs and certification requirements that have changed little in twenty years, and given the appearance of half a dozen major instructional "innovations" during this period, it should come as little surprise that many teachers feel less than well-qualified to teach what they are teaching. Approximately 12 percent of the teachers questioned in the NSF-sponsored studies said they felt inadequately qualified to teach one or more of their present courses. Moreover, of those teachers, the vast majority listed courses that fell **within their own subject areas**. Most of the science teachers who said they did not feel adequately qualified in all areas were referring to courses within the discipline of science.

In what specific areas do teachers feel they need assistance? Not in lesson planning or actually teaching lessons, but rather in obtaining information about instructional materials, in learning new teaching methods, in implementing the discovery/inquiry teaching approach and in using manipulative (or "hands-on") instructional materials.

Where do teachers turn for information about, and help with, new instructional approaches? Most rely on other teachers. Other particularly valuable sources of information listed by teachers include: journals and other professional publications, college courses and local inservice programs, principals, district subject specialists, federally sponsored workshops, meetings of professional organizations and publishers and sales representatives. The majority of teachers, on the other hand, rated teacher union meetings and state education department personnel as "not useful."

Several threads are common to the successful adoption of new instructional materials and approaches by teachers. First, teachers must be informed about, preferably involved in, the curricular reform or change; why the change in the first place and the goals and intent of the new program. Next, teachers must be instilled with commitment to **use** these changes. Finally, training programs must guide teachers in using new materials and techniques, drawing upon real classroom situations. All too often inservice training has disregarded what really goes on in the classroom.

BARRIERS TO EFFECTIVE TEACHING

If school district officials are interested in making sure teachers keep pace with curriculum developments, they might well begin by taking a look at what teachers themselves perceive to be barriers to effectively adopting new teaching or curricular methods. In priority order of mention, teachers say:

Lack of consultant services

Lack of supplies

Inadequate room facilities

Lack of sufficient knowledge

Lack of inservice opportunities

Inability to improvise

Unfamiliarity with methodology

Studies have shown that when the above barriers are removed or reduced, the quality of instruction does, in fact, improve. In short, then, funds for new curricula materials will be wasted unless districts work to remove these barriers and to provide incentives which will prompt teachers to adopt the new materials or techniques.

References

A series of reports comprising an NSF-sponsored study of the status of the nation's elementary and secondary school educational practices in science, mathematics and social studies is now available. Three major approaches were used—literature review, case study and survey.

A. The literature review, contracted to Dr. Stanley Helgeson, Ohio State University, examined published and unpublished documents related to existing needs statements in science, mathematics and social studies. The results of this review are published in three volumes:

> *Volume I: The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Science Education.* Government Printing Office stock number 038-000-00362-3; $4.25.

> *Volume II: The Status of Pre-College Science, Mathematics and Social Science Education: 1955-1975. Mathematics Education.* Government Printing Office stock number 038-000-00371-2; $4.50.

> *Volume III: The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Social Science Education.* Government Printing Office stock number 038-000-00363-1; $6.25.

(The above volumes also are available in microfiche and paper copy through ERIC and The National Technical Information Service.)

B. The case studies covered eleven in-depth investigations of ongoing educational practices. This study was contracted to Drs. Robert Stake and Jack Easley at the University of Illinois-Urbana. The case study findings are available in a 16-volume set, in sixteen separate volumes, or in a 2-volume set.

> *Volume I: Case Studies in Science Education. The Case Reports.* Government Printing Office stock number 038-000-00377-1; $7.25.

> *Volume II: Case Studies in Science Education. Design, Overview and General Findings.* Government Printing Office stock number 038-000-003763; $6.50.

> *Case Studies in Science Education*—16-volume set.

(The above volumes also are available in microfiche and paper copy through ERIC and the National Technical Information Service. Also available from NTIS are the sixteen separate volumes in paper copy and microfiche at prices ranging from $3.00 to $8.00. The separate volumes are available from ERIC in microfiche [$0.83 each] and paper copy [$1.67 to $8.69].)

C. The national survey of teachers, principals and superintendents regarding training, materials and educational practices was contracted to Dr. Iris Weiss of Research Triangle Institute. The survey findings are reported in one document. Further, the raw data is available on computer tape accompanied by a user's manual.

> *Report of the 1977 National Survey of Science, Mathematics, and Social Science Education.* Government Printing Office stock number 038-000-00364-0; $6.50. Also available through ERIC and NTIS.

> *Data Tape and User's Manual for the 1977 National Survey of Science, Mathematics and Social Studies Education.* Available only from NTIS. Accession number PB284331/AS. Paper copy, $16.25; microfiche, $3.00.

The eighth document currently available includes the status study overview as well as summary documents from the three interrelated studies. The report is titled *The Status of Pre-College Science, Mathematics and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies.* Government Printing Office stock number 038-000-00383-6.

Analysis: The NSBA Curriculum Symposium

Education is not an exact science with predictable, standardized inputs, processes or outputs; education is as much art as it is science. And just as the processes of education are often abstract and immeasurable, so too are the expectations for the public schools often intangible and in a state of flux.

And as the first part of this report suggests, nowhere does the "science" of education seem less scientific than in the area of curriculum.

Indeed, there is not even a commonly held definition of the term curriculum. Certain educators would tie curriculum solely to content—**what** children are learning through teachers, books and other learning materials. Others would define curriculum as a blend of content and teaching methodology. And irrespective of the technical definitions, one must ask whether curriculum is confined within the schoolhouse walls. Is "curriculum" what a child learns in school, or should experiences outside the classroom be considered part of the curriculum as well?

The answers to these questions, the symposium participants felt, are inseparable from meaningful analysis of the NSF-supported studies. One superintendent pointed out, for example, that in his view, teaching is not a part of curriculum per se; therefore, although teaching methods may have remained constant over the past two decades, this does not necessarily indicate that there have been no changes in curriculum or in students' classroom experiences. To accurately measure change, then, this superintendent argued, educators must first agree on what it is they are trying to measure.

However, having faulted the NSF-contracted studies for not adequately defining curriculum, the participants in the meeting found that they, too, could not agree on a precise definition of the term. This lack of concensus suggests that notions of curriculum vary according to the perspectives, needs and concerns of school officials. One fundamental task before school boards, then: to establish definitions of—and goals for—the district's curriculum.

Several of the symposium participants felt that while the findings of the NSF-supported research are generally sound, the reports tend to overstate the negative aspects of math, science and social studies education. They believed that the researchers were overly critical, that there has been more sustained movement in curriculum than the reports imply. These views will be explored in the next section of this report.

Others in the group felt that the NSF-contracted researchers seemed to advocate change for the sake of change. As a board member from Arizona put it, "While I agree that the classroom situation has changed very little over the past twenty years, I'm not convinced this is necessarily bad. For instance, we tried team teaching, an innovation, on two elementary grade levels and it worked some excellent teachers to death without producing any significant change in student achievement." In this case, the more "traditional" approach proved more effective, the board member maintained.

A curriculum specialist from the Midwest voiced similar sentiment: "Our district has intentionally taken a cautious approach to changing the curriculum; we haven't jumped on every passing innovation bandwagon. We've tried new approaches on a limited basis and have expanded them only if they proved successful."

The fourteen educators generally agreed, then, that change in itself is not a desirable curricular goal.

Local Experiences

Some of the districts represented at the meeting, however, apparently have managed to implement **productive** change in the classroom. Most of these reforms emphasized greater use of inquiry-based instruction and manipulative materials (such as laboratory equipment)—modes of instruction that have had only minimal impact on children's classroom experiences, the NSF-sponsored studies suggest. In addition, several participants reported that while teaching strategies may not have changed markedly, the variety of course offerings has expanded considerably. For instance, science courses today include nuclear physics, ecology and general relativity—topics not offered in the 1950s.

Even when curricular innovations did not take hold, however, they often influenced successive programs. Even in schools where it is not in use today, BSCS biology—which gained popularity in the mid-1960s—has affected the teaching of biology in its emphasis on comparisons of biological systems and its downplaying of rote memorization of the animal kingdom.

Pitfalls in Curriculum Reform

Perhaps the strongest thread running through the discussion at the NSBA symposium was that school boards have not exerted enough leadership in the area of curriculum. The educators agreed with the finding that special interest groups and teacher organizations have garnered and bargained increasing power in curriculum decision-making. Moreover, the symposium participants felt that school boards tend to react to these pressure groups, rather than taking the primary active role in the curriculum decision-making process.

Why the lack of steady curriculum development? Participants suggested several possibilities.

By nature, school boards are representative bodies; as such, many boards have been quick to respond to what they believe the public wants. In the late fifties, for example, the public endorsed the federal government's goal to reach the moon and the public schools responded with expanded and modernized math and science instruction. More recently, many districts have redoubled their emphasis on basic skills in response to growing public demands for accountability and concern over declining student test scores. Indeed, the back-to-basics movement and related spinoffs—such as minimum competency testing—now set the course for much of the curriculum "reform" in American public schools. The Buffalo, N.Y. schools, for example, recently revised their math curriculum to meet new state regents examination requirements which will be in effect by 1981.

While acknowledging the presence and impact of demands for accountability, most of the educators NSBA convened cautioned against developing curriculum in reaction to minimum competency tests. They pointed out, for example, one of the inherent problems in teaching for tests: the tendency to place more emphasis on memorization and recitation of facts than on learning processes. This stifles student initiative and inquiry-building skills and, in turn, further enhances the already dominant role of the textbook as the primary source of learning.

So, too, do current economic conditions directly affect curriculum reform in the schools. One board president ventured that many schools are emphasizing the three Rs not because school officials believe they're all children need, but because tight fiscal conditions have forced them to pare many course electives and to curtail spending to develop new instructional programs. As the NSF-sponsored research points out, school districts no longer have money available for the new supplies and textbooks imperative to many curriculum innovations.

In some cases, school officials are being haunted by the past. One curriculum specialist opined that, in the beginning 1960s, schools started promising more than they could deliver. During this period many schools were quick to adopt and implement new methods and materials before they were tried and tested; the results were not always promising. This helped spawn a credibility gap between educators and the public, as schools adopted untried instructional innovations while, at the same time, promising more qualitative education. As a by-product of this credibility gap, a cynical public is often unwilling to accept—or pay for—curricular innovations in the schools today.

One of the biggest stumbling blocks to effective implementation of new curricula, as pointed out earlier, has been insufficient inservice training for teachers. Often, districts simply do not have the funds or staff to adequately train teachers in the use of new instructional materials. Other times, the training that is provided proves insufficient to meet the needs of the teachers. A Midwestern curriculum specialist illustrated this point. In the sixties, his district adopted *Concept and Values and Man: A Course of Study* (MACOS) as basic elementary texts. Because the materials contained in these series were open-ended, requiring the skills and strategies of inquiry and problem-solving, the programs necessitated inservice training for all elementary teachers. A good number of the teachers whose teacher preparation courses had stressed the teaching of historical facts found the inservice training inadequate. In the end, many of the busy elementary teachers reverted to familiar materials and methods. Only when teachers went beyond this inservice training to take summer workshops were they able to successfully apply the new approaches in the classroom. Several other educators reported similar experiences in the area of inservice training.

Due largely to growing constraints imposed by collective bargaining, many districts are finding it increasingly difficult to convince teachers to work beyond the regular school day to get involved in workshops held in conjunction with new curriculum implementation. Teachers, via their union negotiators, are now challenging programs pre- and post-school hours without extra pay or other concessions from the board. In addition, more and more work contracts now include stipulations which give teachers a greater hand in textbook selection, district staffing decisions and items that affect other school employees, such as paraprofessionals.

A variable over which school boards have no control—demographics—has influenced curriculum, the fourteen educators agreed. A superintendent from Massachusetts attributed the scarcity of lasting curricular innovations to the school population explosion of the 1960s. Districts had to provide more staff and facilities, and local financial and human resources were directed to these areas rather than to the overall curriculum. Paradoxically, in the 1970s, curriculum reform is endangered by the reverse phenomenon; declining enrollment. School districts no longer need to purchase as many new books and materials; consequently, it is difficult for the innovations to reach the classroom.

In summary, the key obstacles to meaningful change in curriculum identified by the fourteen school officials attending the symposium include:

Lack of school board initiative

Impact of the back-to-basics movement

Insufficient funds for materials and supplies

Inadequate inservice training

The impact of collective bargaining

Lack of public confidence in the schools

Prospects for Curriculum in the Years Ahead

What can school boards do to help ensure more effective curriculum development in the future? Most importantly, boards need to re-examine and revitalize their roles in this important area, the fourteen school officials attending the NSBA symposium concluded.

STRENGTHENING SCHOOL BOARD LEADERSHIP

Above all else, it is the school board's responsibility to set the philosophical framework—and to provide adequate resources—for curriculum development.

School board members should see to it that curriculum considerations are not pushed aside by other board business. Too often the board meeting agenda is devoted exclusively to business items, leaving no time for discussion of what is happening to students in the classroom. And as another component of their leadership role, boards need to increase their influence in federal and state legislation affecting curriculum.

CURRICULUM AS A PROCESS

The symposium participants also concluded that curriculum is best viewed as a **process** rather than as a **product**. As a process, curriculum concerns are ongoing; the school district should set annual goals and should continually assess progress toward those goals. Further, if the board establishes a written policy to regularly review the curriculum, subsequent decisions will become matters with which the public expects the board to deal. All too often today the public views curriculum as an area outside the board's sphere of control. And, of course, by its very nature, identifying curriculum as an ongoing process allows for change.

BROAD-BASED PARTICIPATION

By encouraging input from a wide variety of actors—school staff, students, parents and others in the community—school districts should be better able to develop curricula that reflect "mainstream" opinion rather than "single issue" perspectives. While school boards are elected to deliver what the public wants, board members must not feel pressured to adopt every instructional innovation which appears on the horizon. For example, the public may be clamoring for more "basic" education, while the board believes that developing thought processes is equally important. In this case, it is the task of the board to make sure that children are learning the basics while they also are learning how to think. As one curriculum specialist put it: "There is a strong movement in the public mood away from logic and reason toward indoctrination. School boards and administrators must continue to provide curricula that teach children how to use their brains in logical and reasoned ways . . . This development of the thinking and reasoning ability should be the ultimate basic skill."

ROLE OF THE SUPERINTENDENT

Two of the most important jobs confronting school boards, the educators agreed, are developing a curriculum policy that strikes a balance between the desires of parents and the public and what the board views as educationally sound, and hiring a chief administrator who will then effectively implement that policy.

Establishing a cooperative relationship between the school board and the superintendent emerges as especially important; to a great extent, board members are dependent on their chief administrator to advise them on curriculum matters. One board president explained that art, music and physical education specialists were removed in grades one through three in her district. These services were still provided, but without the help of specially trained teachers. Board members did not have the necessary background to decide whether or not this move was educationally sound, and therefore had to accept the superintendent's evaluation of the situation.

Another participant suggested that school boards would be wise to release the superintendent from certain management duties in order to allow him more time for what he was really trained to do—to handle instructional concerns.

While board members must trust and depend on the superintendent's advice on curriculum matters, school boards should be careful not to relinquish their decision-making responsibilities. To avoid this potential abrogation, one superintendent suggested that boards should establish a policy making it the responsibility of the superintendent to provide curriculum "inservice" for board members. This type of training directly addresses one of the problems—lack of information needed to make wise decisions—which the NSF-sponsored studies identified as an impediment to curricular changes.

The meeting participants identified a key charge to school boards: regardless of budget constraints, boards should put money aside to hire curriculum experts. Boards must also see that teaching and administrative staff have the time and resources to plan, test and evaluate curricular programs.

PLANNING FOR THE FUTURE

Finally, boards must plan curriculum with an eye toward the future, the school officials said. Education, as one participant noted, is subject to a 20-year half-life: half of what students are now learning in school will be of no value twenty years from now; conversely, half of the knowledge that will be needed in two decades does not even exist today. Boards therefore must be flexible, allowing for growth and change in curricula, yet working to develop and build upon sound, established goals and objectives for the overall instructional program.

Trends to Watch for in Curriculum Planning

Looking toward the next decade, participants identified a number of trends and developments that likely will affect curriculum:

> **Continuing enrollment declines.** Because materials do not need to be placed as often as they did a decade ago, the development of new types of instructional materials will most likely slacken.
>
> **The "tax revolt."** As citizens are squeezed by inflation, tax and budget-limiting initiatives are likely to be adopted in more and more areas. As such, schools will be finding it more difficult to purchase new curriculum materials and to allocate new dollars for curriculum development.
>
> **Collective bargaining.** Increasingly, teachers are demanding—and often obtaining—more say in curriculum matters through provisions negotiated with school boards. This trend could accelerate as boards, finding less money for staff salaries and benefits, are tempted to make concessions on non-monetary items, such as curricular matters.
>
> **Energy crisis.** Steadily climbing school operating costs further curtail funds available for curriculum.
>
> **Ethnic awareness.** The presence of minority groups—their culture and history—is increasing in textbooks and instructional programs.
>
> **Changing structure of the family.** As the number of working mothers and single-parent households continues to rise, schools may be called upon to expand their roles—to provide day-care and education services for adults in the community.

Gordon Cawelti, executive director of the Association for Supervision and Curriculum Development, offered further insight into trends that will affect curriculum in the future.*

Implication for Local School Curriculum in the Years Ahead

While education analysts disagree in their particular scenarios, most agree that the future will be determined by a combination of change and human choice.

On the assumption that the future depends on choices made today, there are four areas of concern about the curriculum in which leadership and assistance are needed.

Assisting teachers in the use of educational technology. One education expert contends that ten years from now only one-half the public funds currently being spent for education will be available. Already, about half the states have enacted legislation which curtails the ability of state or local government units, including schools, to increase their funding levels. Given the present inflation rate—and increasing expectations about services the public schools should provide—such funding cutbacks would be onerous indeed. Schools may be forced to reduce instructional services in several areas or to sharply limit certain areas of youth development—driver education, nutrition and counseling, for example.

---

*Excerpted from testimony presented to the U.S. House of Representatives Subcommittee on Elementary, Secondary and Vocational Education; April 26, 1979.

However, another alternative may exist to help balance budgets. Schools are now a labor intensive industry with 85 to 90 percent of their funds earmarked for personnel costs. If the financial situation demands it, however, schools could become more "capital intensive," making greater use of technology and media for courses involving training, such as mathematics and reading. Curriculum leaders or teachers would probably not deliberately choose this approach, but it may become necessary in the face of increasing budgetary pressures. This concept, however, will not be useful for all of education; many areas of the curriculum are not appropriate for heavy reliance on technology.

To date, computer-assisted instruction, dial access audio and video tapes, calculators and other technology have penetrated the market in only a limited way. This may be due to teachers' uncertainty on how to use technology and an inadequate software development system. It is clear that schools will need assistance if this shift toward greater use of technology in the classroom becomes a reality.

Expanding the locus of learning. Sociological analyses have revealed widespread change in the structure and fabric of society. Schools have taken on, from the home, church and community, growing responsibility for both the socialization and the intellectual development of youth.

Can this "let the school do it" attitude be reversed? It can; indeed, it must be. The total community must assume more responsibility in the education process. Federal assistance is needed to help mobilize new structures within the community which would work to see that our youth are given learning and growing opportunities within the community. Such efforts would give students a better sense for career opportunities, the role of social service in the community, and the connection between education and the world of work.

Human resource development. Purposeful, lasting changes in the school curriculum cannot take place unless teachers receive training to update their talents and techniques. All too many of the present staff development and inservice training programs across the U.S. are dreadfully ineffective in actually producing improved teaching or better management skills in administrators.

Why? The level of support for staff development activity at the state and local level is woefully inadequate. It is imperative, therefore, that local school districts, and state and federal education agencies, plan and develop a well-planned and systematic approach to staff training and development. Because of the ebbing influx of newly trained personnel and the corresponding "aging faculty" phenomenon, this preparation for the future is essential.

Redefining general education. One final question remains to be answered: how shall we define the program of general education which will prepare students for the year 2000? (General education here refers to the base or core program for all youth.)

The secondary curriculum now consists of an extensive series of course offerings, a few of which are required, most of which are electives. These courses, organized along traditional subject-area lines, have reflected two recent phenomena:

> The addition of courses to the curriculum which attempt to reflect contemporary interests of youth; and
>
> The attempt of school officials to respond to social and personal problems via the school curriculum. Courses on drug education, consumer education and ethnic studies now are common to many school systems throughout the U.S.

These two developments have contributed to the creation of a "patchwork" curriculum: a curriculum which lacks coherence and any systematic sense of preparing youth for the future. Further, current efforts to require demonstrated competencies as a requisite to graduation are likely to prolong this patchwork curriculum.

Problems we face today, and those we will confront in the future, involve complex and interrelated vectors—the environment, the economy, population, energy, food supplies and continued industrialization, to name a few. Unfortunately, the present separate-subject curriculum does not reflect this interaction of diverse fields of knowledge.

To adequately prepare students for an uncertain future, schools must develop interdisciplinary curricula. In addition to consolidating content areas, schools must redefine "basic skills" to include areas such as self-directed learning, conserving, relating and coping.

While the federal government has been and must be sensitive about any semblance of a national curriculum, local districts need help in setting into motion a curriculum development process which will help them start a reconceptualization of general education. This commitment to local curriculum responsibility must be preserved and cultivated; the federally sponsored Rand studies of change in education have demonstrated that large-scale federal interventions into the curriculum change process have had very limited effect.

All societies use their schools' curricula to transmit their culture and values. Unfortunately, we have optionalized the curriculum so much that we are no longer transmitting much of anything. School board members must be encouraged to rethink the purposes and objectives of the public schools; tough decisions and specific objectives must be set. Some educators, indeed some students and parents, may question the level of change which has been proposed here. But this redefinition of general education is imperative if schools are to provide the knowledge and skills which will be necessary for survival in the twenty-first century.

The NSBA Panel on Curriculum Trends and Developments

School board members

Florence E. Baugh
Buffalo Public Schools
Buffalo, New York

Gladys Eddy
Poudre Public Schools
Fort Collins, Colorado

Clair R. Geiger
Wauseon Public Schools
Wauseon, Ohio

Vic Hooper
Balsz Elementary School District
Phoenix, Arizona

Panel chairperson
Rob L. Olcott
National School Boards
Association

Superintendents

Don Bloom
Enid Public Schools
Enid, Oklahoma

Leonard Servetter
Chula Vista Public Schools
Chula Vista, California

Walter Shanks
Putnam County Public Schools
Cookeville, Tennessee

Ralph Wachter
Calvert County Public Schools
Prince Frederick, Maryland

John W. Wynn
Tewksbury Public Schools
Tewksbury, Massachusetts

Curriculum Specialists

Ron Anderson
York Public Schools
York, Nebraska

Kenneth Berg, Deputy Supt.
St. Paul Public Schools
St. Paul, Minnesota

Cliff Gillies
Mukilteo Public Schools
Everett, Washington

Collins W. Henson
Hazelwood School District
Florissant, Missouri

Wanda Jowell
Houston Public Schools
Houston, Texas

National School Boards Association

Hiroshi Yamashita, President
Thomas A. Shannon, Executive Director

James Betchkal, Associate Executive Director, Office of Program Services
Lee VanBremen, Assistant Executive Director, Special Services Section

Rob Olcott, Director, Information Services
Lisa Roth, Information Assistant

☆ U.S. GOVERNMENT PRINTING OFFICE: 1980 O— 326-669

best copy available

National Science Foundation
Washington, D.C. 20550

Official Business

PENALTY FOR PRIVATE USE, $300

RETURN THIS COVER SHEET TO ROOM 233, IF YOU DO NOT WISH TO RECEIVE THIS MATERIAL ☐, OR IF CHANGE OF ADDRESS IS NEEDED ☐ (INDICATE CHANGE, INCLUDING ZIP CODE).

Postage and Fees Paid
National Science Foundation

U.S.MAIL

SPECIAL FOURTH CLASS RATE
BOOK

SE 80-9